

# Chemical & Process Engineering

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## *Chemical Engineers in Sun Helmets*

SO much is heard about chemical engineering in big, continuous chemical plants and oil refineries that one of the main jobs of the chemical engineer in this world—helping the underdeveloped countries to upgrade their raw materials—often goes unnoticed. Nevertheless, the sun-helmeted chemical engineer who is helping to upgrade raw materials in Asia and Africa is no less important than his steel-helmeted brother who treads the catwalks of some great oil refinery.

Indeed, the former might well regard himself as a participant in a very noble cause—that of preserving peace in the world—since the best insurance against the poverty and discontent that lead to war is for the more advanced countries to help underdeveloped areas to make the most of their natural resources and to raise their standard of living.

In the field of technical assistance such organisations as the Technical Assistance Administration of the United Nations and the Food and Agricultural Organisation are constantly active, though the importance of the work they do does not get sufficient recognition and support from industry. In Britain, a report\* issued by the Federation of British Industries dispels the illusion,

cherished by some, that the efforts of such international bodies are unrealistic and remote from the interests of industry. It shows that, on the contrary, it would repay consulting engineers, contractors and manufacturers to keep closer touch with this work and to co-operate wherever possible.

One need that has been pointed out is for the injection into the underdeveloped countries not only of capital and know-how, but also technical personnel. And here, of course, comes the snag that there are not enough experts to go round. Where chemical engineers are concerned, Britain at least has her own shortage to think about, and, as another example, an article in this issue makes it plain that in a related field—mineral dressing—there is a shortage of experts even in the most advanced European countries.

The answer is surely that all efforts must be made to train personnel from the underdeveloped territories in the more advanced countries, and any co-ordinated plans for the training of engineers and scientists in Europe must take this need into consideration. At the same time, commercial firms with capital in the underdeveloped countries can help themselves and the world in general by providing training for the nationals they employ in their plants.

\* "United Nations Technical Assistance." Federation of British Industries, 1955. Pp. 38, 2s. 9d.

## **Atomic energy and the Commonwealth**

ELSEWHERE in this issue some of the chemical engineering and other work carried out by the Atomic Energy Research Establishment at Harwell is briefly noted. Britain's lead in the peaceful uses of atomic energy was evident at the recent international conference at Geneva and, when the conference was over, Britain flew foreign visitors to Harwell and back to Geneva again so that they could learn some more about British work in this field. This typifies the British attitude to atomic energy, with its emphasis on the need for international co-operation.

Another feature of the British effort is the close co-operation that has been maintained with other Commonwealth countries. Currently the most significant contributions of the Commonwealth, apart from Canada and the U.K., are the actual and potential supplies of uranium and other materials needed for nuclear development. Sources of uranium include the Rum Jungle and Radium Hill deposits in Australia, and the gold-mining industry in South Africa, while New Zealand's main contribution to nuclear development is likely to be provision of heavy water from its geothermal steam project at Wairekei. India, which has important deposits of uranium and the largest deposits of thorium in the world, has an impressive atomic energy plan.

The Central Office of Information in London has recently prepared a booklet entitled 'The Commonwealth and Nuclear Development' (H.M.S.O., 2s.). This first surveys briefly the story of atomic energy and the British contribution to it; it then describes progress in other Commonwealth countries and finally deals with international co-operation.

## **Oil refinery maintenance and repair increase**

Maintenance and repair servicing is an increasingly important item in British oil refineries and, now that the construction stage of the post-war development has largely been completed, periodical shut-downs come into prominence as well as normal engineering maintenance. If the total sum currently invested in British-owned refineries both at home and overseas may be estimated at some £250 million, the annual expenditure on maintenance and repairs may be taken as some £6½ million, taking into account wear and tear and corrosion but not obsolescence.

This estimate, which does not include modernisation, is made by the chairman of the Council of British Manufacturers of Petroleum Equipment, Mr. Douglas Wilson, in his report for 1954-55, and he urges petroleum equipment manufacturers to make sure that they are able to meet the demands that will be made upon them. The call for equipment, materials and services for maintenance and repair must be regarded as bound up with after-sales service where British equipment has been supplied in the first place and as an opportunity for British enterprise where this has not been the case.

Mr. Wilson's comments on this matter are supported by the observations of the Council's technical adviser,

Mr. T. L. Bonstow, who points out that some indication of the importance of this phase is given by the example of British Petroleum Co.'s East Kent refinery, where, he calculates, the cost of the maintenance work for this new plant must be about £2 million p.a., increasing annually. This estimate is based on the fact that some 540 men will be continually engaged in keeping the plant in efficient running order.

The trend in processing is more reforming of naphthas and desulphurisation. The latter is accomplishing two objectives: recovery of elemental sulphur and improvement of gas oil and diesel oil, to the benefit of the users of these kinds of fuel for power generation. In addition to the production of propane and butanes for L.P.G. and of light fractions for petrochemicals, there are now ammonia, acetylene, aromatics, etc.

## **I.C.I. titanium process for U.S.?**

A JOINT application has been submitted to the United States Government by Imperial Chemical Industries Ltd. and Columbia-Southern Chemical Corporation, of Pittsburgh, U.S.A., for a contract under which the Government would undertake for a five-year period to purchase 5,000 short tons p.a. of granular titanium metal. In their application the companies have stated that they have completed arrangements for the introduction into the United States of a granular titanium process not at present employed there and would also make available to fabricators techniques not at present known or employed in the U.S.

If the contract is awarded, they will form a jointly owned subsidiary for the purpose of producing granular titanium metal by I.C.I.'s sodium reduction process. The parent companies will each hold a 50% interest in the new company, which would be known as Columbia Titanium Co. The plant would be built at Natrium, West Virginia, and would have a capacity of 5,000 short tons p.a. The cost of the proposed granular titanium metal plant will be in the region of \$10 million.

I.C.I.'s patent position and production experience have an unusually broad base through their experience of chemical and metallurgical technology. Their patent and process knowledge extend from the production of granular titanium metal by their new sodium process to melting, scrap recovery, alloying, testing, jointing and fabrication, in the latter of which particularly they are favourably placed by virtue of their wide experience in non-ferrous metal technology.

Columbia-Southern's contribution to the proposed joint enterprise lies in the production of titanium tetrachloride, from which granular titanium metal will be made. Itself one of the leading American producers of chemical products, Columbia-Southern, a wholly owned subsidiary of the Pittsburgh Plate Glass Co., has been engaged in research on the chlorination of titanium-bearing ores since 1937. It has established a broad patent position in this field and today licenses other companies under Columbia-Southern patents.

Columbia-Southern and I.C.I. believe that their

## Comical Engineering Terms



"WORM REDUCTION GEAR"

proposal to the U.S. Government will result in lower capital and production costs and in the acceleration of a titanium fabrication industry in America.

### Polythene in chemical engineering

THE new polythene plant that Union Carbide Ltd. are to set up in Scotland (as reported in this issue) is only one manifestation of the interest that this plastics material is arousing. Polythene, a British development, is now produced not only by Imperial Chemical Industries Ltd. but also by several U.S. plants and one Canadian one, while two or three plants have come into operation on the European continent. And now the new Ziegler process for making polythene at low pressure is to be commercialised, as discussed in our associate journal, the *Manufacturing Chemist*, recently.

Polythene, in fact, seems destined to become one of the chief plastics materials of the future—and this also applies where chemical engineering uses are concerned. Its high impact strength and chemical resistance, and in particular its inertness to hydro-fluoric acid, have given it a number of applications for chemical plant. Of these, piping is perhaps the best known at present, but polythene can also be moulded or fabricated into such items as storage tanks, ducting, centrifugal fans and exhaust hoods, and valves, to mention one or two. Hot-gas welding of the material, as exemplified in a range of fabrications by the American Agile Corporation, opens up endless possibilities.

## Edinburgh tries new composting machine

A NEW plant for the rapid composting of domestic and other refuse, built in Manchester and installed by a Danish firm, is being tried out by Edinburgh Corporation. The plant, the first to be installed in Britain, is capable of processing 20 tons/day of refuse with sewage sludge added to the process.

The Dano Bio-Stabilizer, as it is called, is a long, slowly rotating drum which is charged with raw refuse through a feeding device fixed at one end. Along the whole length of the drum air is blown into the mass of refuse through nozzles. By regulating the nozzles aerobic conditions are created throughout. The fermentation temperature can be controlled and temperatures which are lethal to pathogenic organisms can be obtained at will. As the drum rotates the refuse is thoroughly mixed and ground by internal friction. At the same time it moves along the drum to the opposite end, where it is discharged after three to five days, and the fermented materials are then screened out.

Excess heat produced during the decomposition process tends to dry out the materials in the drum and impede fermentation; the inclusion of wet sludge in the process not only allows valuable amounts of organic nitrogen to be added but also provides a means of balancing the moisture content. It is stated that the compost is thus enriched and the sludge is pasteurised and dried at small cost.

The largest unit of this type can subject 50 to 75 tons/day of refuse to biological disintegration.

### Heavy chemicals in Jugoslavia

FOR the economist, an interesting state of affairs exists in Jugoslavia, where a socialist state with communist leanings is attempting to organise the economy of the country along capitalistic lines and in co-operation with the Western world. It is equally interesting to notice how Jugoslavia's chemical industry is affected by these experiments. The five-year plan introduced in 1947 provided for a considerable expansion of the chemical industry, but all kinds of difficulties were soon encountered and only partial implementation was found possible. Since 1953, however, the chemical industry has considerably increased its output, which has now reached about twice the pre-war level. It is still a long way off from satisfying the needs of the country. Jugoslavia no doubt has good reasons for exporting part of this production despite this fact.

The manufacture of sulphuric acid, mainly from iron pyrites, shows a relatively large increase—from 14,000 tons in 1939 to 60,000 tons in 1954—but for a country with 18 million inhabitants even the second figure is not very impressive. Although the demand is far greater than the production (50,000 tons had to be imported) some 1,000 tons were exported to Austria. Plans are under discussion to build a new sulphuric acid plant with a capacity of 50,000 tons p.a. at Subotica and to make use of the waste gases of the copper extraction plant at Bor for making further

quantities of sulphuric acid. The largest sulphuric acid works, with an annual production of 43,000 tons, are at Sabac and belong to 'Zorka Hemisika Industrija.' They use all the acid they make in their own works for the manufacture of superphosphate. They are the only manufacturers of this fertiliser in Jugoslavia and produce 120,000 tons p.a., but the country could easily use more than twice this amount.

The production of soda ash, made by the Solvay process, and of caustic soda—two-thirds made by the Gossage process and one-third by electrolysis—have gone up, the main producer being 'Soda, Fabrika Sode' at Lukavac. A fair proportion of soda ash has been exported to Austria, India, Denmark and Egypt recently, while caustic soda has gone to Brazil, Austria and Turkey.

Reviewing the Jugoslavian industry in *Chemische Industrie* recently, Dr. A. Me states that the production of calcium carbide has fallen from 64,000 to 40,000 tons p.a. Of the present carbide production, 45% is converted into calcium cyanamide, 30% into acetylene, 15% into polyvinyl chloride and 10% is exported.

### Chemicals, ahoy!

SEA transport of chemicals seems to be making a splash in the United States where four chemical concerns are making use of a 16,000-ton tanker converted by Chemical Tankers Inc. and plying between Texas ports and the Atlantic coast. The Monsanto Co. will use almost half the cargo space of the ship, while Celanese Corporation of America, Commercial Solvents Corporation and Columbia Southern Chemical Corporation share the remainder.

For Monsanto, the ship regular operations will pick up styrene and methanol at the company's Texas City plant, and then will call at Freeport Sulphur Co.'s docks at Port Sulphur, Louisiana, to load 2,500 tons of molten sulphur into a specially constructed, heavily insulated hold.

At the other end, the ship at Newhaven, Connecticut, will discharge the liquids (except sulphur) to shore bulk-storage facilities, while the sulphur will be transferred directly into a new ocean-going barge christened *Chemical Progress*. The barge is expected to keep the liquid sulphur at about 285°F. during the 36-hr. tow to Monsanto's Everett, Massachusetts, plant.

For Celanese Corporation, the chemical tanker has a connection with the company's 4-million-gal. storage facilities at its bulk terminal and tank farm at Newark, New Jersey. Celanese will ship more than 1 million gal. of chemicals on each voyage. The company plans to bring in 15 different chemicals from its Texas plants ranging from solvents, such as acetone and alcohols, to intermediates such as formaldehyde and acetic acid. This month the first shipment of bulk glacial acetic acid to be shipped by ocean tanker is scheduled to arrive at the Celanese terminal.

Commercial Solvents has announced improved service on its deliveries of methanol to the east coast through the new tanker run. A clue to the savings in transport costs is given in this company's estimate that

each shipment of methanol will equal the carrying capacity of over 100 railroad tankcars, or 1 million gal.

Columbia-Southern are making use of the tanker to pick up caustic soda shipments from a Lake Charles, Louisiana, port and carry them to the company's tank farm in Carteret, New Jersey.

### Australia's alkali industry grows

REQUIREMENTS of both soda ash and caustic soda in Australia reached the highest levels ever recorded in recent months and it looks as though these levels will be maintained for the rest of 1955 at least. Since, in any country, the consumption of alkalis may be used as a yardstick of general industrial activity, these facts can safely be taken as a sign of the upward trend in manufacturing activity throughout Australian industry.

The glass industry is the largest single consumer of soda ash in Australia. Substantial quantities are also used to make sodium silicate, in the production of aluminium, in mining and in water treatment. Other prominent uses are in soap powders, wool scouring and the paper industry. The two major uses of caustic soda are for making soap and for the production of phenol for the manufacture of plastics. Large quantities are also taken up in food processing and petroleum refining.

According to a report from Australia's Department of National Development, Icianz Ltd. is the only producer in Australia of soda ash and this company is the only large producer of caustic soda for sale. Soda ash is made electrolytically in New South Wales and Victoria, and is also made in South Australia from soda ash. Electrolytic plants are also operated by A.P.P.M. Ltd. (Tasmania), A.P.M. Ltd. (Victoria) and by Timbrold Ltd. (N.S.W.), but the caustic soda produced is not made available for general sale. Sodium bicarbonate is also manufactured by Icianz Ltd. in South Australia, together with by-product calcium chloride.

Plant capacity at the Osborne works was doubled some 2½ years ago to a nominal rating of 100,000 tons p.a. gross of soda ash. This capacity is currently being exceeded.

Additional electrolytic productive capacity for caustic soda came into operation at Botany, N.S.W., towards the end of 1954. Output is planned to increase during 1955 to accord with the chlorine requirements of the current Icianz project for expanding production of polyvinyl chloride. During the six months ending April this year, total Australian production of caustic soda increased by about 10%, being equivalent to about 28,000 tons p.a. Prices at this time were unchanged from April 1, 1954, when soda ash was reduced to £33 17s. 6d. a ton from £35 and solid caustic soda to £70 a ton from £72.

Productive capacity for caustic soda is adequate for current and prospective demand, but demand for soda ash has exceeded the present maximum working capacity of the South Australian plant and small supplementary imports have proved necessary.

# BURSTING DISCS

## AND THEIR USE ON PROCESS PLANT

By J. M. Pirie, PH.D., A.M.I.CHEM.E.

(Johnson, Matthey & Co. Ltd.)

*Bursting discs have an unequalled reputation as safety devices for pressure vessels in the chemical and petroleum industries, and increasing applications are being found for them in other fields. Here is an authoritative survey of the use of bursting discs on process equipment, explaining what they are and what they do, and discussing the types available, advantages and limitations, practical applications, materials of construction, compound assemblies, special applications, and future prospects.*

THE simplest and most certain way of protecting a closed vessel against the effect of over-pressure is to provide a small area in the structure which is very much weaker than the rest. The idea has been used in a crude way for many years, but it is only comparatively recently that, in a new and precise form, it has come into general favour among chemical plant designers.

There are several possible means of providing this deliberately weakened area. They can be classified according to whether the breaking force is provided directly by the energy of the system under pressure, or whether some auxiliary means of breaking the membrane is provided. The great majority of practical designs are in the first group.

### Types of bursting discs

**Direct breaking force.** The most generally employed method is to mount a disc of ductile foil in an accurately machined circular housing with a smoothly radiused lip on the low-pressure side. Under fluid pressure, this disc stretches into a spheroidal form, becoming progressively thinner towards the crown, and it ultimately breaks when the tensile limit of the material at the crown is exceeded. The escaping fluid causes the expanded disc to 'petal' and open up virtually the full bore of the housing for relief.

Circular discs are also employed in other methods, but made of relatively non-ductile materials, and mounted in holders having a sharp rim against which the disc is forced to shear. In some cases a thick plate is secured to the central part of the disc to localise the shearing position. In another



[Albright & Wilson Ltd.]

Fig. 1. Fitting a 4-in.-orifice capsule-type assembly with silver disc into a pipeline.

modification a plate, for instance of cast iron, has an annular groove of determined thickness formed in it to provide a shearing line.

Of all these kinds, the spheroidal

'tensile' disc is much to be preferred. Its bursting pressure is directly related to the thickness of the foil, which can be relatively easily controlled. For a given thickness, bursting pressure in-

creases as the material becomes more ductile, so that, for a particular metal, foil in the fully annealed condition provides the highest possible bursting pressure and any departure from this causes the bursting pressure to be lowered in the direction of safety. The exact form of the holder has little influence on the bursting pressure, provided that the diameter of the orifice is correct.

Shearing discs require not only that the physical properties of relatively non-ductile material shall be exactly controlled, but that the sharpness of the cutting edge shall be exactly the same for every burst and in every similar holder. With the grooved kind, it is necessary to machine an annular cut of exactly identical depth in every disc. These considerations make it inevitable that the bursting pressures of shearing discs are much less predictable than are those of tensile discs. Additionally, in the bursting of a shearing disc the centre portion, which may be quite massive, is nearly always detached and, if there is a considerable release of energy, it may become a dangerous projectile.

At the present time the use of shearing discs is mainly confined to certain special applications in which the orifice is small and where the disc acts both as a safety device and also as a means of opening a pressure vessel for use, when the disc is cut by means of a plunger. An assembly of this sort is shown in Fig. 2.

**Indirect breaking force.** Methods involving indirect breaking force are mainly of use when the relief pressure has to be so low that it is impracticable to roll sufficiently thin foil to obtain a normal tensile burst. The simplest indirect method makes use of a normal tensile disc, but with a needle or knife mounted close behind the centre of the disc on the low-pressure side, so that when the disc stretches under pressure it touches the cutting device, which forms a point of extreme weakness from which the burst is propagated. An arrangement of this sort is described in British Patent 488,953. The chief drawback to the device is the difficulty of pre-setting to an exact bursting pressure, with the risk of far exceeding the prescribed pressure if the cutter is accidentally blunted or displaced. Recently an exceedingly ingenious indirectly actuated device has been introduced by the Graviner Manufacturing Co., particularly suitable where a large relieving area has to be provided for a low-inertia system. The disc is made of toughened glass and is burst by a detonator mounted



[Johnson, Matthey & Co. Ltd.]

Fig. 2. Shearing-type bursting disc assemblies fitted with gold-clad phosphor bronze discs, before and after testing.

close to it, which is fired electrically by a relay system controlled by a pressure-sensitive diaphragm mounted in the vessel to be protected (Fig. 3).

#### Advantages of bursting discs

In many circumstances a correctly designed bursting disc made from tested material is the safest possible means of protecting a pressure vessel. The properties of a tensile disc are such that abnormal conditions, errors in assembly, accidental damage or prolonged neglect always cause it to burst at a lower pressure than that for which it is specified—it cannot by any means be made to withstand a higher pressure.

It has very little inertia and, when the rupturing pressure is reached, the disc opens extremely rapidly, usually in only a few milliseconds, and immediately presents a full-bore opening for discharge. The complete absence of leakage until the moment of rupture is a most important advantage if the equipment is handling costly or toxic materials or if ingress of air must be completely avoided when working under reduced pressure.

Assembly or replacement is simple and straightforward; discs are relatively inexpensive, and they can easily be given positive identification so that the bursting pressure of a particular unit is known to the plant operatives with certainty.

#### Inherent limitations

While it is relatively easy to ensure that any disc will never burst at a higher pressure than that for which it is intended, it is by no means so easy to be sure that it may not burst at a lower pressure. By careful control of the material specification and the processes of fabrication and annealing, and by rigorous testing, the manufacturer of tensile discs can undertake that all discs will burst within not more than plus or minus 5% of the

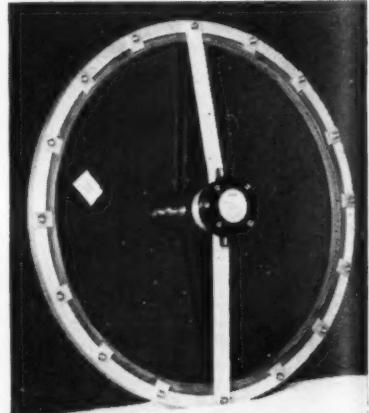
required pressure at a stated temperature when they are supplied.

But in most process equipment the disc will normally be subjected to some positive pressure less than the relieving pressure and, if this working pressure is a substantial proportion of the bursting pressure, the disc will gradually be thinned and weakened by creep forces and will eventually burst even if the normal working pressure is not exceeded.

This is the principal limitation to be borne in mind when the protection of a pressure vessel by bursting discs is under consideration. A vessel protected by a relief valve can usually be worked up to within, say, 10% of the relieving pressure, but similar treatment of a tensile bursting disc would cause it to fail in a few days. Generally speaking, it is undesirable to subject a disc to a continuous pressure which is more than about 70% of its bursting pressure, unless it is practicable to arrange for relatively frequent replacement.

A further limitation is imposed by the effect of temperature. This varies according to the material of the disc, but increased temperature always tends to diminish the bursting pressure. Since it is usually necessary to be sure that the specified bursting pressure at room temperature will not be exceeded, the actual bursting pressure if the disc is exposed to elevated temperature will be less, so that an additional margin between actual working pressure and specified bursting pressure is needed on account of this factor.

The third limitation is imposed by the effect of fluctuating and negative pressures in the system. Discs as supplied are normally predomed by



[Graviner Manufacturing Co. Ltd.]

Fig. 3. An armour-plate-glass bursting disc, 2 ft. in diameter, which is opened by means of a detonator fired by a pressure-sensing device.

fluid pressure to about 85% of the required bursting pressure. Such a disc has very little resistance to pressure applied to its convex face and, if the normal bursting pressure is less than about 100 p.s.i., it will tend to collapse inwards if it is subjected to full vacuum. After one or two reversals of this sort it will, of course, be gravely weakened. The difficulty can be overcome by the provision of a domed perforated support fitted closely to the concave face. This is reasonably effective, but as the disc becomes stretched during use the close fit against the support is partly lost, and there is some crinkling when vacuum is applied. For this reason, discs which must be subjected to positive pressures as well as to vacuum need somewhat frequent replacement.

Once these limitations are clearly understood, their effects can be largely overcome by the correct selection and combination of safety devices, and it is only in rare instances that it is necessary to forego completely the assurance which only a bursting disc can provide.

The final limitation is an obvious one—once a disc has burst, it has burst. If, as is often the case, the discharge must be checked once the over-pressure has been relieved, some secondary device must be installed to enable this to be done. Fortunately, to do this is not difficult.

### Practical applications

In its simplest form, a tensile disc assembly comprises an ordinary flanged branch, made to standard dimensions, with a recess in which the disc is placed, retained by a spigoted backing flange with a smoothly radiused lip, which is bolted down. Since the backing flange is not in contact with the contents of the vessel unless the disc has burst, it can often be made of mild steel. Much more commonly, however, the disc is housed in a separate capsule, which may be either full-face, of the same diameter as the main flanges, or narrow-face to fit inside the main flange bolt circle. The use of capsule holders allows disc replacements to be made much more quickly and ensures that the discs themselves, which are comparatively fragile, need only be handled under workshop conditions (Figs. 1 and 4).

It is also easier with this type of holder to observe the strict precautions which must be imposed to ensure that only a disc of the correct material and specification can be installed in the protected equipment. Disc assemblies should, wherever possible, have some



Fig. 4. Standard full-face capsule-type bursting disc assemblies, with pre-domed silver discs, stainless-steel holders and vacuum supports.



Fig. 5. A small-bore bursting disc unit with a screwed holder, protecting a gas storage cylinder.

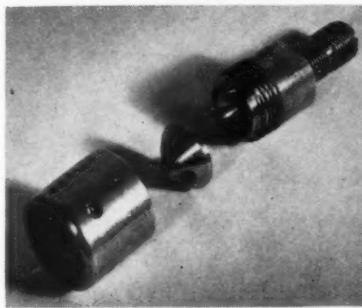


Fig. 6. A cone-ring bursting disc holder intended for use at high pressures.

form of mechanical coding or interlock, to prevent them being fitted into the wrong unit.

When the orifice size is less than about 1 in., self-contained screwed holders are generally used, as shown in Fig. 5. The patented cone-ring holder shown in Fig. 6 is intended to provide a uniform grip on the disc rim, to ensure reliable behaviour at high bursting pressures.

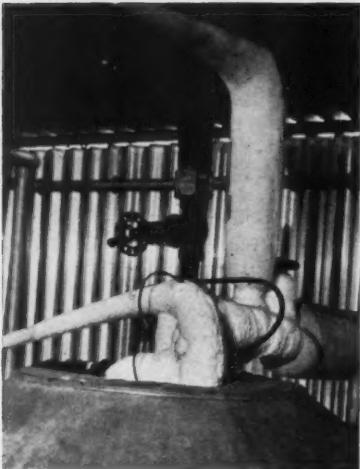
Whatever type of holder is employed, it is essential to prevent the accumulation of dirt or rust on the down-stream face of the disc. Sharp fragments between the disc and the orifice ring, cutting into the foil, may easily reduce the bursting pressure to less than half the correct value.

### Materials of construction

**Metal.** The disc holder, and often the vacuum support, can usually be constructed of the same material as the equipment on which it is mounted. The disc itself must usually be of a different material. In the first place, it must be ductile, capable of being rolled into thin foil and must have metallurgical characteristics which are reproducible from batch to batch—this requirement leads to the choice of pure metals rather than alloys in all possible cases—it must also be as nearly as possible completely resistant to the corrosive effects of the contained fluid, since although attack at the rate of, say, 0.005 in. p.a. may well be acceptable in a shell  $\frac{3}{8}$ -in. thick, it can cause a startling change in the bursting pressure of a disc only 0.003-in. thick. Where the chemical conditions are suitable, aluminium, copper or nickel are frequently employed; silver is extremely serviceable over a comparatively wide range of conditions, while—if severely corrosive substances are to be handled—gold, palladium or platinum may be necessary. The only alloys employed to any extent are copper-nickel, and the austenitic stainless steels.

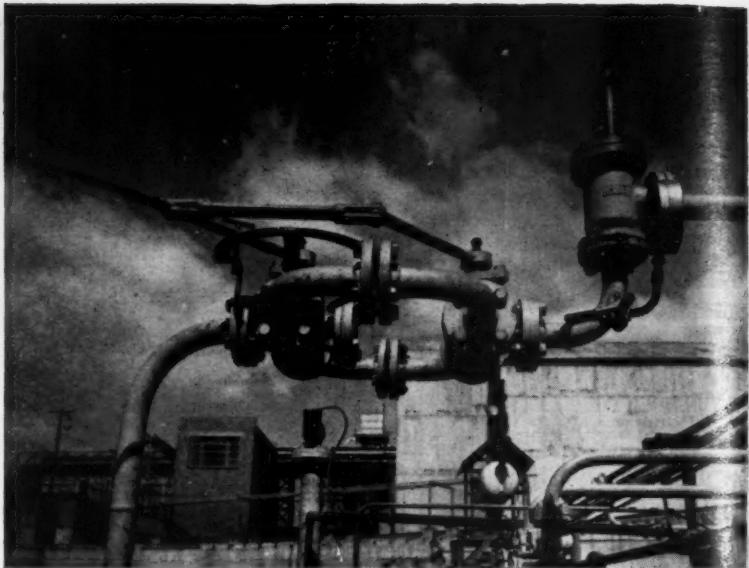
**Non-metal.** Discs made of non-metallic materials have so far been used to a very limited extent, because of the difficulty of obtaining reproducible bursting pressures from batch to batch and because non-metals tend to change in characteristics with the passage of time even more than metals.

They are, however, sometimes useful when very low bursting pressures are required—tensile discs made of polyvinyl chloride have been made to burst quite consistently at only 2 or 3 p.s.i. Recently impregnated carbon discs have become available in America which may have useful advantages.



[The Distillers Co. Ltd.

Fig. 7. A screwed-type bursting disc assembly, mounted in series with a locked-open stop valve, protecting a bulk storage tank for liquid carbon dioxide. The disc outlet is covered with a thin rubber membrane to prevent condensation.



[Figs. 8, 9, 10 and 11, courtesy: Albright & Wilson Ltd.

Fig. 8. Bursting disc assemblies with copper discs, in parallel arrangement on methyl chloride storage tank.



Fig. 9. Bursting disc assembly with silver disc, mounted between a reaction vessel and a relief valve.

These discs are rigid, and shatter when the prescribed bursting pressure is reached. They can be made to burst within close limits at comparatively low pressures; for instance, a 4-in.-orifice disc about  $\frac{1}{8}$ -in. thick will burst at 20 p.s.i. Since the bursting pressure under negative pressure is approximately the same as the normal one, no vacuum support is usually needed and the adverse effect of fluctuating pressure on disc behaviour should be mitigated.

#### Compound assemblies

Because of the limitations which have already been discussed, the simple set-up with a single disc discharging directly to atmosphere is not usually sufficient on process equipment; some more elaborate arrangement is almost always called for.

The prime need is usually to ensure that escape of the vessel's contents can be halted when the over-pressure has been relieved. Where the rate of escape is low, this can be done by

fitting a stop valve adjacent to the disc, which must of course be locked open during operation (Fig. 7). A more elaborate arrangement is shown in Fig. 8, in which similar discs are fitted in parallel branches, with a three-way cock controlled by a lever by means of which the line is isolated after a disc has burst, and the relief opening diverted to the parallel disc. The most usual way, however, is to fit a relief valve, downstream from the disc, which will lift at about the same pressure as the disc will burst. Once the over-pressure is released the valve will re-seat and working can continue until an opportunity to replace the disc arises.

This arrangement forfeits the benefit of very rapid and complete venting, so that it is not suitable if a sudden increase in the energy of the system must be anticipated and, at first sight, the presence of the disc may seem superfluous, but it enables the valve to be protected from gummy fluids or polymerisation products, and from corrosion, except during the brief period before disc replacement. It avoids completely the loss of toxic or valuable products during all periods of normal operation. Examples of this arrangement are shown in Figs. 9 and 10. The pressure gauge mounted between the disc and valve gives notice that the disc has failed and avoids the danger of an unknown increase of pressure in the interspace, which would of course increase the bursting pressure.

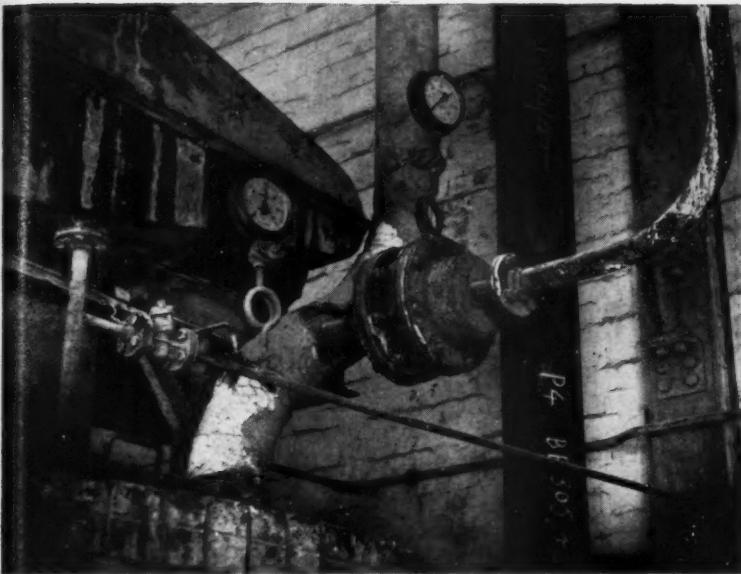


Fig. 11. Two bursting disc assemblies with silver discs, fitted in series on a drying vessel.

The effect of temperature can best be minimised by mounting the assembly on a sufficiently long branch pipe to take it clear of the source of heat or, if this is not possible, a short branch with a cooling jacket can be used, or the disc itself can be sprayed or flooded with coolant.

The tendency of discs to fail prematurely can be minimised in two ways. In the arrangement shown in Fig. 11 it can be seen that two discs are mounted in series, with an intervening pressure gauge. Should the upstream disc burst prematurely, this will be indicated by the gauge, but the downstream disc, which has so far been unstressed, will carry the normal working load until a shut-down gives an opportunity for replacement. If the pressure in the system reaches the specified bursting pressure, both discs will of course rupture in succession and venting will take place normally. In the other arrangement, shown in Fig. 12, a disc assembly and a relief valve are mounted on parallel branches, the valve set to lift at the safe working pressure and the disc at some higher pressure, but not above the hydraulic test pressure. In this way the disc is placed at a pressure sufficiently above the normal working pressure to avoid the risk of premature failure, but it still protects the vessel effectively against the consequences of a stuck or gummed-up valve, or an abnormal energy release arising from a fire or similar cause.

The replacement of large discs

mounted in a pipeline can be a troublesome job. Fig. 13 shows an arrangement in which jack screws are used to open the flanges between which the capsule is mounted. In Fig. 14 the pipe is enlarged into a box, so that the disc assembly is made readily accessible in spite of its size.

The bursting of a large disc with a high energy release may be accompanied by a considerable reaction, and this must be taken into account in the design of mounting for the pressure vessel and, if practicable, by fitting a recoil plate.

Some attention must also be given to the exit of the discharge pipe; if the vented fluids are toxic or obnoxious they may need to be led to a sufficiently large receiving tank fitted with a fluid seal or relief valve.

#### Some special applications

Although their use for the protection of process equipment in the chemical and petroleum industries is probably best known to chemical engineers, the particular advantages of bursting discs are becoming quickly recognised in other industries.

Possibly the most novel application is in the system of explosion suppression developed by the Graviner Manufacturing Co., in which the propagation of an explosion either of vapour or dust in a closed vessel is prevented by the discharge of a suppressant fluid. The suppressant is confined in a hemispherical silver or copper container, which is ruptured by firing an



Fig. 10. Close-up view of bursting disc assembly and relief valve on a re-boiler column.

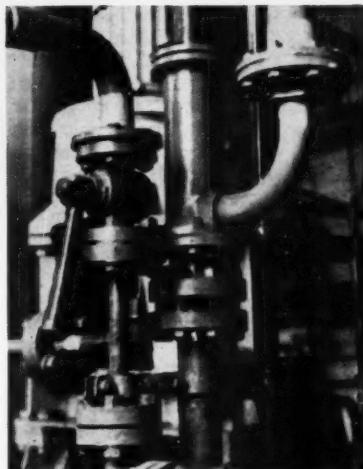


Fig. 12. Parallel arrangement of bursting disc and relief valve.

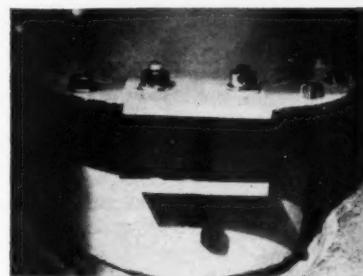


Fig. 13. Flanges with jack screws, for a large bursting disc assembly.

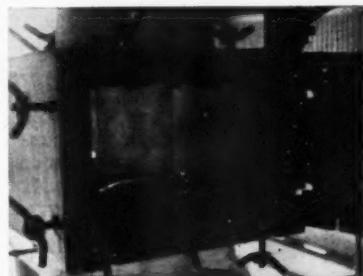


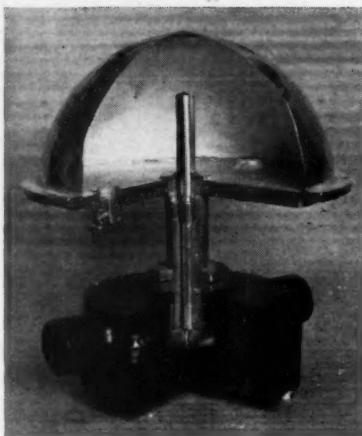
Fig. 14. A large bursting disc assembly made easily accessible by means of a box-type mounting.

internally mounted detonator actuated by a relay system controlled from a pressure-sensitive diaphragm inside the vessel to be protected.

Fig. 15 shows the hemisphere assembly sectioned to reveal the interior arrangement; the container is formed by fluid pressure like a domed tensile disc, so that it is thin at the crown, and bursts petal-fashion under a known pressure to discharge the contents in a uniform spray.

The protection of refrigerating compressors and compressor systems with bursting discs is well-established practice; the necessity for completely preventing either loss of refrigerating fluid or leakage into the system is an obvious cause for their use, most frequently in combination with a relief valve. It has recently been possible to develop comparatively large tensile discs that will burst at pressures as low as 3 p.s.i. and they are now being applied to the protection of large vessels such as power-station condensers, wind tunnels and gasification plants, where a low relieving pressure is required and a conventional relief valve would be unduly cumbersome and costly.

There are, of course, a number of uses in Service equipment, of which the protection of cartridge-operated engine starters is a typical example.



[Graviner Manufacturing Co. Ltd.  
Fig. 15. Sectioned view of an explosion suppression unit, in which the hemispherical disc is burst by means of a detonator fired by a pressure-sensing device.

A relief valve does not generally give protection if a vessel is unexpectedly placed under negative pressure, but it has been possible to safeguard a large absorber by placing a disc, set to burst at about 7 p.s.i. differential pressure and fitted with a support, facing inward so that it will withstand the positive pressure of normal working but will burst if the internal pressure falls below about  $\frac{1}{2}$  atm.

### Present limits and future prospects

The practical range of disc sizes is from about  $\frac{1}{4}$ -in.-orifice diameter up to 20 in. They can be made to burst at any chosen pressure from about 3 p.s.i. up to 10,000 p.s.i. or above. The highest practical operating temperature is about  $400^{\circ}\text{C}$ , and virtually any type of corrosive attack can be accommodated. Under most conditions discs can be supplied to burst within a pressure range of  $\pm 5\%$ .

It is not likely that the accuracy of bursting will need to be much increased, but a better understanding of the causes of disc deterioration is needed to free the user from the present risk of premature bursts. Work in this direction is going forward.

A need yet unfulfilled is for discs, preferably corrosion and heat resistant, which will burst in small orifices at very low pressures—at present it is usually necessary to have a disc larger than would otherwise be specified, if the bursting pressure is to be low.

Standardisation is in progress at present and, before too many years have passed, users may expect to be able to find a correlated range of discs and assemblies to suit almost every normal requirement.

## Italy makes Fluorides

THE manufacture of fluorides as a post-war development of the Italian chemical industry was made possible by the ample supply of the mineral fluorspar which occurs in association with quartz, carbonates and sulphides. Indeed, so much fluorspar is mined in Italy that about 85% goes for export—mainly to U.S.A. Last year the fluorspar production reached 100,000 tons and nearly three-quarters of all the mineral mined came from the Val Brembana and the Val Trompia mines of the Società Mineralia Prealpina, Milano.

Last year 72% of all the fluorspar used in Italy was converted into hydrofluoric acid and fluorides, while 22% was used as a flux in iron foundries—particularly in the open-hearth process for making steel, where it gives fluidity to the slag and assists in the removal of such impurities as sulphur and phosphorus. The rest went to the glass and the ceramics industries.

Hydrofluoric acid is made by two firms—Bonelli, Dolzago (Como), and Montecatini (Milan)—and their pro-

duction amounts to 37,000 tons p.a. The capacity of the two plants is much greater, but the present production covers the demand. The main uses are the manufacture of fluorides, including synthetic cryolite, glass etching, purification of graphite, sterilisation of fermentation vessels and the manufacture of filter paper. Cracking catalyst for the petroleum industry is another end product.

The same two firms are the only manufacturers of sodium aluminium fluoride, i.e. synthetic cryolite. They make use of the hydrofluosilicic acid obtained as a by-product in the manufacture of superphosphate from phos-

phate rock containing calcium fluoride. Last year they produced  $2\frac{1}{2}$  million tons, of which 40% was exported. The production is likely to rise, as the demand of the aluminium industry is growing and the synthetic material is about 30% cheaper than the mineral imported from Greenland.

The demand for sodium fluoride is decreasing. Only 75 tons were produced last year and used for metallurgical purposes, for the manufacture of casein glue and for impregnating wood for the mines. The fluorides of chromium, potassium and ammonium were made in small quantities.

According to a survey by L. Vidotto in *La Chimica e l'Industria*, the manufacture of fluorine is still in its infancy, but as the raw material is abundant and the difficulties of preparing it have been overcome, further important developments are only a matter of time. Amongst the fluorine chemicals which might be manufactured in Italy in the near future are the fluorochloro paraffins, which have exceptional advantages as working fluids in refrigerating systems, and fluorinated resins, which show a very high resistance to extremes of temperature.

### To Authors

The Editor welcomes practical articles and notes on chemical engineering and related subjects with a view to publication. A preliminary letter or synopsis outlining the subject should be sent to the Editor, CHEMICAL & PROCESS ENGINEERING, Stratford House, 9 Eden St., London, N.W.1.

# HEAT TRANSFER

**Thermal conductivity; convection fundamentals; recuperation; condensation; boiling evaporation; fixed and fluid beds; radiation, etc.**

By J. MOSS, PH.D.

PERHAPS the most important addition to the literature on heat transfer in the past year was the third edition of 'Heat Transmission' by McAdams.<sup>1</sup> All the chapters have been enlarged and new ones are included dealing with 'compact exchangers,' 'packed and fluidised systems' and 'high-velocity flow and rarefied gases.' The section on radiant-heat transmission by H. C. Hottel is much fuller than previously, and the emissivity charts of gases now include NH<sub>3</sub> and CO. The results of much Government-sponsored work that has recently been released for publication have been included, *e.g.* on heat transfer to liquid metals and on rockets and gas turbines.

## Conduction

Chung and Jackson<sup>2</sup> have developed an unsteady-state method for the determination of the thermal diffusivity of some low-conductivity materials. This method determines directly the diffusivity as opposed to the conventional determination of the conductivity and then the specific heat. Similarly a periodic heat-flow method was used by McIntosh *et al.*<sup>3</sup> for the rapid determination of the thermal diffusivities of several metals, *i.e.* Armco iron, titanium, zirconium and Hayes' Stellite 25.

A horizontal parallel-plate apparatus was used by Dick and McCready<sup>4</sup> to determine the thermal conductivity of 19 liquid organic compounds, and the experimental values were correlated with their molecular structures. Woolf and Sibbitt<sup>5</sup> used a concentric cylinders apparatus to determine the thermal conductivities of five liquids not investigated before, *i.e.* Dowtherm A and E, fin oil, Circo XXX heat-transfer oil and Aroclor 1254. A similar apparatus was used by Mason<sup>6</sup> to determine the conductivity of some industrial liquids from 0 to 100°C. and he has compared his results with those of previous workers. Boggs and Sibbitt<sup>7</sup> have measured the conductivities of hydrocarbon and silicone polymers and some extremely viscous

aqueous solutions with viscosities up to 60 million c/s. Jenkins and Reid<sup>8</sup> have investigated the conductivity of 33 liquid silicone compounds. A nomograph giving the thermal conductivity of organic liquids, which has been compiled on the basis of a large amount of published data, has been presented by Kharbanda.<sup>9</sup>

A compensating hot-wire type of apparatus was used to investigate the conductivity of furfural liquid and vapour by Schmidt and Spurlock.<sup>10</sup> The conductivity of molten lithium has been measured from 420 to 1,002°F. by Webber *et al.*<sup>11</sup>

Hilsenrath and Touloukian<sup>12</sup> have issued a report on the thermal conductivities, viscosities and Prandtl numbers of air, O<sub>2</sub>, N<sub>2</sub>, NO, H<sub>2</sub>, CO, CO<sub>2</sub>, H<sub>2</sub>O, H<sub>2</sub> and A, from 100 to 2,000°K.; this was based on recent critical correlations of these properties by the National Bureau of Standards. Keyes<sup>13</sup> has extended his previous work on the determination of the conductivities of diatomic gases and has now investigated the conductivities of other gases, *i.e.* five rare gases, N<sub>2</sub>O, CH<sub>4</sub>, NH<sub>3</sub>, C<sub>2</sub>H<sub>6</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>2</sub>Cl, CCl<sub>2</sub>F<sub>2</sub>, (CCl<sub>2</sub>F<sub>2</sub>)<sub>2</sub>. A chart from which the thermal conductivities of gases can be determined if the viscosities and specific heats are known has been compiled by Johnson and Huang.<sup>14</sup>

## Convection fundamentals

A summary of the N.A.C.A. research on heat transfer and friction for air flowing through tubes with large temperature differences has been given by Pinkel;<sup>15</sup> the tubes examined were both circular and non-circular in cross-section and had walls of various roughnesses. Eckert and Diaguila<sup>16</sup> have discussed the results of experiments conducted by the N.A.C.A. on mixed, free and forced convection heat transfer in turbulent flow through a vertical tube with a length-to-diameter ratio of 5.

Kays *et al.*<sup>17</sup> used both steady- and transient-state test techniques to determine the heat-transfer and friction characteristics for gas flow normal to

tube banks with Reynolds numbers from 500 to 20,000. They presented tentative correlations for the effects of the staggering arrangements of the tubes and the number of tube rows.

The effect of single roughness elements on the heat transfer from a 1:3 elliptical cylinder was investigated by Seban *et al.*<sup>18</sup>

Susa and Levy<sup>19</sup> have analysed theoretically the heat transfer to constant-property, laminar-boundary-layer wedge flows, with stepwise and arbitrary wall-temperature variations, based on presupposed velocity distributions.

The heat transfer and fluid friction for fully developed turbulent flow of air and supercritical water with variable fluid properties has been examined by Deissler;<sup>20</sup> the conclusions from his theoretical examination of the process agreed well with his practical results.

Salamone and Newman<sup>21</sup> have proposed the use of an apparent viscosity when using ordinary design equations for the calculation of the heat-transfer characteristics of aqueous solid suspensions.

The effect of simultaneous mass transfer on the heat-transfer coefficient has been investigated by Cairns and Roper<sup>22</sup> for the particular case of heat and mass transfer at high humidities in a wetted-wall column. They found that the theory of Colburn and Drew on this effect of the mass transfer was unable to explain their data.

Johnson *et al.*<sup>23</sup> have determined the heat transfer to lead bismuth and mercury flowing in pipes under both laminar and transition conditions, *i.e.* Re 1,000 to 10,000. They found that the Nusselt values at the lower Reynolds numbers were lower than expected, which they thought was due to a non-parabolic velocity distribution.

They have also<sup>24</sup> investigated the heat transfer to non-wetting mercury in turbulent pipe flow; the results were lower than expected by comparison with those for lead bismuth and much lower than those arrived at theoretically.

## Recuperators

A critical survey has been made by Klinkenberg<sup>25</sup> of various methods for evaluating the heat transfer in double cross-flow heat exchangers. Cass *et al.*<sup>26</sup> have discussed alternative cross-flow-path configurations in refractory recuperators and have derived mathematically the effective temperature differences. Dusinberre<sup>27</sup> has presented a number of explicit iteration formulae and computation guides for the calculation of transient temperatures in heat exchangers and pipes. Rizika<sup>28</sup> has calculated the thermal lags in both counter- and concurrent-flow heat exchangers. Performance curves of modern recuperators, when used with furnaces burning solid, liquid or gaseous fuels, were given by Brown,<sup>29</sup> and the economic effects of the operating variables were examined.

A study of a cylindrical baffled exchanger, in which the shell-side internal leakage has been eliminated, has been made by Bergelin *et al.*<sup>30</sup> This study illustrates the loss in heat-transfer capacity of many exchangers due to internal leakage or by-passing on the shell side.

Hobson and Weber<sup>31</sup> have described a unique type of extended surface or spined tube for heat exchangers in which a large number of spines are shaved from the surface metal of the base tube. An article<sup>32</sup> describing various finned tubes for heat exchangers now being produced in Britain also summarises their properties and the conditions suitable for their employment.

**Regenerators.** The design and operation of high-performance regenerative-type air preheaters for recovering the heat from flue gases have been described by Braddon and Waitkus.<sup>33</sup>

## Condensation

Seban<sup>34</sup> has made a theoretical examination of the mechanism of film condensation with turbulent flow; he has applied analogy calculations of the Prandtl Karman type to the film, and the results agreed with Colburn's theories. He has used this method to calculate the rate of condensation of liquids of low  $\Pr$ , *i.e.* molten metals.

An approximate method for designing cooler condensers, *i.e.* with condensation in the presence of a non-condensable gas, has been proposed by Cairns,<sup>35</sup> who has also reviewed recent papers on this subject. A graphical method for the determination of the correct condensed liquid temperatures in cooler condensers has been worked out by Bras,<sup>36</sup> and Cary<sup>37</sup> has indicated

a method for determining cooler condenser wall temperatures using psychrometric charts. Gilmour<sup>38</sup> has also presented suitable methods of calculation for this case of condensation in the presence of a non-condensable gas in the fifth paper of his series on short cuts to heat-exchanger designs.

A mechanism of condensation for vapours of water and immiscible organic liquids has been proposed by Tobias and Stoppel<sup>39</sup> and was used to produce a modified Nusselt type of equation. They consider that the organic component condenses as a film while the water condenses as droplets on the film surface. Nomographs for calculating the condensation rate of the vapours of non-miscible liquids have been presented by Gilmour.<sup>40</sup>

A new-pattern sectional condenser has been described<sup>41</sup> which is built of interchangeable cast sections with integral water-cooling passages, and is made in both 12-in. and 18-in. diameters. This would appear to be particularly useful in pilot plant or other work where flexibility and interchangeability of equipment is important.

## Boiling evaporation

The local surface coefficients of heat transfer have been determined by Clark and Rohsenow<sup>42</sup> for boiling degassed distilled water flowing upwards in a vertical nickel tube.

Gilmour,<sup>43</sup> as the basis of a rapid method for the determination of the heat transfer in reboilers, has proposed as an approximation that the vaporisation rate is independent of the liquid velocity.

## Fixed and fluidised beds, etc.

Hanratty<sup>44</sup> has proposed a mechanism for the heat transfer in a packed bed whereby a mass of fluid is thrown against the wall, assumes its temperature and then moves into the interior of the bed. On this basis he derived an equation for the heat transfer which he found to agree with practical results for cylindrical packings but not with those for spherical packings.

The heat and mass transfer in a fixed-catalyst bed during regeneration has been discussed by Van Deemter,<sup>45</sup> and more particularly the temperature distribution during the oxidation of a coke bed by a gas with a low oxygen concentration.

A new pebble heater design has been described by Nord<sup>46</sup> in which the fuel is fired directly into the heater.

The heat transfer in fluidised beds has been measured by Wamsley and

Johanson<sup>47</sup> by the transient heating of cold fluidised particles in a hot stream of fluid.

The heating of small reactors by means of a fluidised bath has been described by Adams *et al.*<sup>48</sup>

## Radiation

The radiant heat transfer from various types of flames in a turbojet combustor has been measured by Topper.<sup>49</sup> The intensity of radiation from the flame increased rapidly with increase in combustor inlet pressure, and also varied with fuel air ratio and air mass flow. The total radiations from the luminous types of flame were from 4 to 21 times as great as those from the non-luminous types. Almost all the radiant energy was released in the primary combustion zone; in some cases this was the major mechanism of heat transfer to the liner.

Genna *et al.*<sup>50</sup> have investigated a particular type of gas-fired furnace operating with a non-luminous flame at from 1,750 to 2,110°F. They have analysed the contributions made to the total by the different modes of heat transfer, and concluded that 80% of the transfer occurred by radiation to the charge from the furnace walls and the remainder by convection and gas radiation. Previous methods of calculating the heat transfer in a continuous reheating furnace have been discussed by Sargent and Smith.<sup>51</sup> They concluded that the furnace should be considered in sections for the purpose of the calculations, and that particular attention should be paid to the radiation exchange between sections. Cantle and Aref<sup>52</sup> have investigated both practically and theoretically the shape factors for tube banks enclosed on three sides by refractory surfaces. A new type of radiant burner and its employment in a new tubular heater were discussed by Kreipe,<sup>53</sup> particularly with respect to the geometrical configuration of the tubes and the radiators.

Snyder<sup>54</sup> has undertaken an interesting review of the thermal radiation constants currently in use, and has found appreciable variations in the numerical values used by different writers. He found a 1% variation in the values used for the Stefan Boltzmann constant which, though negligible of course for most engineering calculations, can be of importance in some experimental work.

## Miscellaneous

Oldshue and Gretton<sup>55</sup> have measured the heat-transfer coefficients of helical coils in a mixing vessel equipped with

a flat-bladed turbine impeller. Burke and Kemeny<sup>56</sup> described a novel cooling method for gas-turbine blades. Water was sprayed on to the blades from orifices located near the trailing edges of the turbine nozzle guide vanes. Results of tests with supercharger gas temperatures between 1,150 and 2,350°F. were presented, and the effect of the cooling on the cycle efficiency, and the mechanism of the cooling, were discussed theoretically.

An aspect of the heating of scrap steel in an open-hearth furnace has been examined theoretically by Daws and Collins.<sup>57</sup> They have estimated the decrease in melting time caused by the convection heat transfer from the flame gases that penetrate to parts of the charge not heated directly by radiation.

Kraemer and Westwater<sup>58</sup> have presented a digital computer solution for the heat transfer to temperature probes.

Peterson *et al.*<sup>59</sup> have determined the maximum permissible flow rates in a continuous gas analysis apparatus which depends on the determination of the thermal conductivity by the hot wire method.

The use of media other than steam for the high-temperature heating of distillation plant has been discussed by Pennell.<sup>60</sup> Dowtherm, oil or gas fuel, and electricity are among the media discussed. Various types of direct-fired heaters available for use in the chemical industry have been considered by Olley,<sup>61</sup> and some heating problems and points of interest to intending purchasers were examined. Eyth and Faber<sup>62</sup> have described a variety of available electric heaters of both conduction and radiation transfer types, including tubular, fin, strip and cartridge heaters.

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## A New Guide to British Chemicals

The Association of British Chemical Manufacturers have issued the 1955 version of their directory, 'British Chemicals and their Manufacturers.' This edition is more comprehensive than the 1953 one and contains some 12,000 products named systematically in accordance with British Standard 2474: 1954—'Recommended Names for Chemicals Used in Industry.' The 192-page book contains several sections; in the first, chemicals and allied products are divided into seven groups, and A.B.C.M. members, listed alphabetically, are linked with these various groups by code letters. This is followed by a directory of members and then a classified list of products and also a classified list of indicators and microscopical stains, suppliers being indicated by code numbers. The code references are given on a separate card. A further section lists proprietary and trade names in alphabetical order and, finally, there is an illustrated section on proprietary and trade marks.

Copies of this publication are available free to firms or individuals interested in the purchase of chemicals. Enquiries should be addressed to the Association of British Chemical Manufacturers.

## Plastics Materials and Machinery

A new guide has been published by the British Plastics Federation entitled 'Buyers' Guide to Plastics Materials and Machinery and Equipment for the Plastics Industry.' The guide, a 62-page booklet costing 2s. 6d., has been considerably extended and includes particulars of materials in semi-processed forms such as sheet, tubing, etc. There is also a completely new section dealing with machinery and equipment for the plastics industry.

The names and addresses of the member companies supplying each type of material and machinery are given and the trade names used shown. All are indexed for ease of reference. At the head of each section of materials there is a note giving the principal properties and the more important applications of the material concerned.

# A Note on MULTI-STAGE GAS WASHING

By R. Long, PH.D., ASSOC.M.INST.GAS E.

(Chemical Engineering Department, University of Birmingham)

The concept of an absorption tower made up of theoretical plates is a familiar one to chemical engineers. Essentially the same—although the fact is not immediately apparent—is the concept of a multi-stage gas washer made up of theoretical stages. Here, Dr. Long discusses both these methods in turn and makes their similarity clear.

**C**OMPARATIVELY few books have been written specifically for students of gas engineering. A recent valuable publication which includes a short account of the principles underlying the cooling, washing and purification of coal gas is that of Hopton.<sup>1</sup> The student of gas engineering who pursues the subject of gas washing further, however, may find some difficulty, since textbooks on chemical engineering including the important monograph of Sherwood and Pigford<sup>2</sup> appear to adopt a somewhat different method of approach.

The purpose of this note is to draw attention to the basic similarity between the concept of multi-stage washing as exemplified by the treatment of Hollings and Silver<sup>3</sup> and the concept of theoretical plates used in many chemical engineering textbooks. Much of the difficulty probably arises from the use of different symbols and units in the various treatments of this topic.

## Concept of multi-stage washer

Hollings and Silver consider a washer divided into a number of stages (a multi-stage washer) and base their derivations upon certain assumptions, *viz.*, that

- (1) gas and liquid streams flow through the washer in opposite directions;
- (2) the whole of the liquid in any stage may be regarded as homogeneous;
- (3) the temperature remains constant throughout;

- (4) Henry's law applies to the absorption; and
- (5) steady state conditions exist in the washer.

Consider a washing system of  $n$  stages (numbered in the direction of liquid flow) in which the concentration of solute is reduced from  $G_0$  to  $G_1$  by washing with a fixed amount of liquid. It may be assumed that the gas volume does not change appreciably on washing, the amount of absorbable constituent being small.

$G_0$  = concentration (weight per unit volume, e.g. lb./cu.ft.) of solute in entering gas.

$L_0$  = concentration of solute in entering liquid (lb./cu.ft. of liquid).

$G_r$  = concentration in gas leaving stage  $r$  and passing to  $r - 1$ .

$L_r$  = concentration in liquid leaving stage  $r$  and passing to  $r + 1$ .

$q$  = flow ratio  
 $= \frac{\text{liquid volume per unit time}}{\text{gas volume per unit time}}$

$k$  = partition factor  
 $= \frac{\text{concentration in liquid}}{\text{concentration in gas}}$

It is assumed that the gas reaches equilibrium with the liquid in each stage, e.g. liquid of concentration  $L_n$  will be in equilibrium with gas leaving the stage  $n$  of concentration  $G_n$ .

By Henry's law,  $L_n = kG_n$ .

If the liquid entering the washer is pure solvent containing no solute, then  $L_0 = 0$ .

The concentration of liquid leaving

the  $n$ th stage is then given by an overall material balance across the whole washer.

$$L_n = \frac{G_0}{q} - \frac{G_1}{q}$$

In the  $n$ th stage of the washer the concentration in the gas falls from  $G_0$  to  $G_n$  in contact with liquid of concentration  $L_n$ . A graphical representation can be adopted and the above change is then depicted by the first vertical step in Fig. 2 and so on for the other stages.

$$\text{Also, } L_{n-1} = \frac{G_n}{q} - \frac{G_1}{q} \text{ etc.}$$

In Fig. 2, the equation of the operating line is

$$L_r = \frac{G_{r+1}}{q} - \frac{G_1}{q}$$

and the slope of this line is in fact decided by the value chosen for  $q$ , the flow ratio.

This enables the number of theoretical stages to be deduced in any given case by following the above stepwise procedure.

If  $S$  is defined as the fraction of the solute in the gas that passes unabsoed through the washer,

$$S = \frac{G_1}{G_0}$$

If  $L_0 = 0$ , Hollings and Silver have shown by an algebraic method that:

$$S^1 = \frac{G_0 S - L_0/k}{G_0 - L_0/k} = \frac{qk - 1}{(qk)^n + 1 - 1}$$

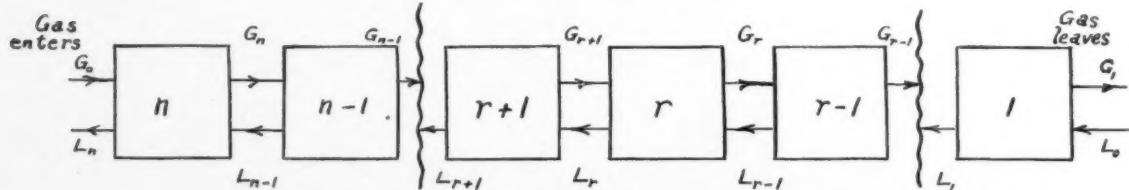


Fig. 1. Gas and liquid flows in a washing system of  $n$  stages.

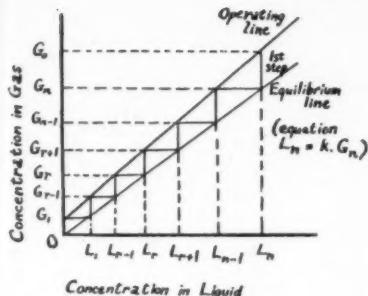


Fig. 2. Graphical representation of theoretical stages for a gas-washing system of  $n$  stages.

This equation expresses the slip  $S$  in terms of the inlet concentrations of solute in the gas and liquid, the flow ratio, the partition factor and the number of stages  $n$ . They use the term virtual slip and the symbol  $S^1$  for the above quantity, for  $L_0/k$  represents the concentration below which it is impossible to reduce that in the gas by the use of entering washing liquid of concentration  $L_0$ .

#### Concept of a theoretical plate

Just as a washer may be considered to be made up of theoretical stages, it may also be considered to be made up of theoretical plates. Absorption towers are widely used in gas absorption operations and, although these may be of either the plate or packed type, the theoretical plate concept may be used in design calculations

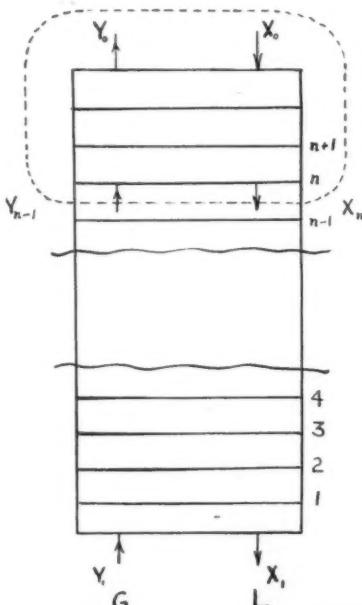


Fig. 3. Plates of an absorption tower.

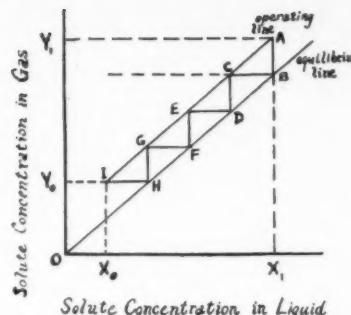


Fig. 4. Graphical representation of conditions in an absorption tower.

(although other methods are available<sup>2</sup>). This method will now be illustrated and it will be seen that it is essentially the same as the method discussed above.

So-called stoichiometric units will be employed, thus the inlet gas rate will be expressed in lb. inert carrier gas per hour per sq. ft. of tower cross-section, and so on.

The horizontal lines in Fig. 3 represent bubble-cap or other plates in an absorption tower. The gas to be treated passes upwards and is brought into intimate contact with liquid flowing downwards. In the case of a theoretically perfect plate the gas leaving it will be in equilibrium with the liquid leaving the same plate (just as in the case of a theoretical stage). It is, therefore, possible to represent the relation between gas and liquid compositions leaving any plate by the so-called equilibrium curve for the system.

$Y_n = m \cdot X_n$ , where  $n$  refers to any particular plate;

$Y_n$  = solute concentration in gas leaving plate  $n$  (lb. solute per lb. inert gas);

$X_n$  = solute concentration in liquid leaving plate  $n$  (lb. solute per lb. solvent); and

$m$  = slope of equilibrium curve.

Considering the material balance in terms of the  $n$ th plate of such a tower,  $G(Y_{n-1} - Y_o) = L(X_n - X_o)$

$$Y_{n-1} = \frac{L}{G} X_n + \left( Y_o - \frac{L}{G} X_o \right)$$

This equation represents the operating line of slope  $L/G$  on a plot of  $Y$  against  $X$ .

In Fig. 4, the point  $X_1, Y_1$ , represents the bottom of the absorption tower, while  $X_o, Y_o$ , represents conditions at the top.

A stepwise procedure enables the number of theoretical plates required to be calculated.

#### Plate efficiency

The number of actual plates required will be greater than the number of theoretical plates determined in the way described.

For further information the reader is referred to the monograph of Sherwood and Pigford,<sup>2</sup> and to the paper of Hollings and Silver<sup>3</sup> for information on the 'efficiency of a bay' in multi-stage washers.

Kremser,<sup>4</sup> and Souders and Brown<sup>5</sup> derived an expression relating the compositions  $Y_1$  and  $Y_o$  of the gas entering and leaving the absorption tower to the number of theoretical plates  $n$  (assuming the equilibrium to be expressed by a linear relation).

$$\frac{Y_1 - Y_o}{Y_1 - mX_o} = \frac{\left(\frac{L}{mG}\right)^{n+1} - \left(\frac{L}{mG}\right)}{\left(\frac{L}{mG}\right)^{n+1} - 1}$$

$\frac{Y_1 - Y_o}{Y_1 - mX_o}$  represents the ratio of the actual change in gas composition in the column to the change that would occur if the gas leaving at the top were in equilibrium with the liquid entering.

This quantity may be shown to be equal to 1 minus the virtual slip

Hollings and Silver relation	Kremser, Souders and Brown relation
partition factor	
$k = \frac{L}{G} = \frac{\text{lb. solute/cu.ft. liquid}}{\text{lb. solute/cu.ft. gas}}$	$\frac{L}{mG} = \frac{\text{lb. solvent/hr.sq.ft.}}{\text{lb. solute free gas/hr.sq.ft.}} \times \frac{1}{m}$
$q = \frac{\text{cu.ft. liquid}}{\text{cu.ft. gas}}$	$\frac{1}{m} = \frac{\text{lb. solute/lb. solvent}}{\text{lb. solute/lb. inert gas}}$
$\therefore qk$ (a dimensionless ratio)	$\equiv \frac{L}{mG}$ (a dimensionless ratio)
and Henry's law is expressed: $L = kG$	and Henry's law is expressed: $Y = mX$
$G_o - G_1 = \text{change in gas concentration in passing through washer in lb. solute/cu.ft. inlet gas}$	$Y_1 - Y_o = \text{change in gas concentration in passing through absorber in lb. solute/lb. inert gas}$

(i.e.  $1 - S^1$  in terms of the symbols used by Hollings and Silver) in the accompanying panel.

Let  $Y_1 - Y_o = c(G_o - G_1)$ , where  $c$  is a constant for conversion of units.

$$\text{Then } \frac{Y_1 - Y_o}{Y_1 - mX_o} \equiv \frac{c(G_o - G_1)}{c(G_o - L_o/k)}$$

$$= \frac{G_o - G_o S}{G_o - L_o/k}$$

$$\therefore \frac{Y_1 - Y_o}{Y_1 - mX_o} = 1 - S^1$$

$$= 1 - \left( \frac{G_o S - L_o/k}{G_o - L_o/k} \right) = \frac{G_o - G_o S}{G_o - L_o/k}$$

$\therefore 1$  minus the virtual slip =  $1 - S^1$

$$= \frac{(qk)^{n+1} - qk}{(qk)^{n+1} - 1} \text{ (in Hollings' and Silver's symbols)}$$

$$= \frac{\left( \frac{L}{mG} \right)^{n+1} - \left( \frac{L}{mG} \right)}{\left( \frac{L}{mG} \right)^{n+1} - 1}$$

Fig. 5 is a graphical representation of this relationship in which the ratio

$\frac{Y_1 - Y_o}{Y_1 - mX_o}$  is plotted as ordinate

against the ratio  $L/mG$  (or  $qk$ ) as abscissa. Several curves are drawn showing the effect of the number of plates or stages.

This diagram shows that, for a high recovery of the solute, either a large number of plates or stages must be used or the absorption factor must be large.

For any given system,  $m$  (or  $k$ ) is fixed by Henry's law so that the absorption factor is increased (at constant temperature) by increasing the flow ratio (ratio of liquid flow to gas flow).

If  $L/G < m$  (or  $qk < 1$ ) the absorption is definitely limited no matter how many plates or stages may be used. It can be shown that the minimum quantity of liquid necessary to give complete absorption of the solute in an ideal washer is given by  $L/G = m$  (or  $qk = 1$ ).

It will be noticed that for this maximum possible absorption the necessary liquid/gas ratio is independent of the concentration of the absorbable constituent in the gas.

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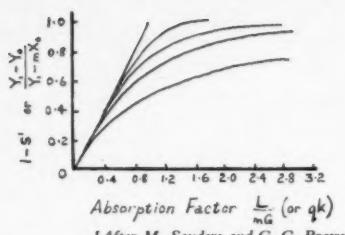


Fig. 5. Relation between column performance and number of theoretical plates. The curves, reading upwards, are for 1, 2, 4, 12 and  $\infty$  stages respectively.  
[After M. Souders and G. G. Brown]

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## Copper Tubes and Cylinders

Copper tubes and cylinders have numerous uses in chemical and general engineering, instances being brewing coppers, distillation plant, equipment used in several food industries, and in the manufacture of such varied substances as paper, textiles and oxygen. Copper is also well known as a material for heat exchangers and pipelines containing steam, compressed air, vacuum, petrol, oil or refrigerants.

The grades of copper most widely used in the manufacture of copper tubes are phosphorus deoxidised non-arsenical and phosphorus deoxidised arsenical copper. Copper plate and sheet which are to be manufactured into vessels for chemical and similar purposes are normally also of deoxidised material. The main advantage of deoxidised copper as compared with oxygen-bearing (tough pitch) copper is that it is not susceptible to hydrogen embrittlement during annealing, welding or brazing.

Engineers who are concerned with copper tubes will be interested in an illustrated booklet, 'The Strength of Copper Tubes and Cylinders,' which is issued free by the Copper Development Association, Kendals Hall, Radlett, Herts. The effects of working conditions are considered in it and, after referring to recently published research work, guidance is offered on design principles. A bibliography, a list of British Standards and some

alignment charts are included. Discussing safe stresses in copper, it is shown how in practice the elastic limit of copper at normal temperatures can be exceeded with the utmost safety, and it is pointed out that designers and users should become accustomed to the fact that in soft or half-hard copper tubes or cylinders a small initial deformation under working stress is usually not a sign of weakness or impending failure, but can safely be permitted. It can be avoided in most cases only by uneconomical design.

Short-term mechanical properties become even more misleading at elevated than at ordinary temperatures, and a knowledge of the creep properties of copper becomes essential. Copper, in common with all materials, decreases in creep strength as the temperature rises; for temperatures of 400°F. and over the use of the very hard tempers is actually disadvantageous, and arsenical copper is superior to non-arsenical copper as far as creep strength is concerned.

For high-pressure applications copper can, if desired, be reinforced by steel. Composite or clad tubes are available, and cylindrical vessels can also be made from copper-clad steel; alternatively, copper vessels can be strengthened by winding with steel wire or strip. Cylindrical shells, especially the ends of cylinders, can be fortified by means of copper or steel stays. It should, however, be remembered that, where steel and copper are in contact in the presence of certain liquids or atmospheric moisture, the normal rate of corrosion of the steel is liable to be accelerated.

As regards the design of cylindrical vessels under external pressure, many theories and empirical formulae have been developed, and descriptions of them will be found in textbooks on the strength of materials and on the design of pressure vessels. Reference may also be made to Provisional British Standard Code 1500: 1949, 'Fusion-welded Pressure Vessels for Use in the Chemical and Allied Industries.' While some of these formulae constitute a good basis for design, the most economical results can often be achieved only by practical tests.

**Rotary piston blowers** and exhausters are the subject of an illustrated brochure from Sturtevant Engineering Co. Ltd. The machines are designed to blow or exhaust clean air or other clean gas against resistances which are beyond the scope of centrifugal blowers.

# South Africa's Industries Make Progress

Chemical Engineering Techniques Play Increasing Part

By W. Williams

## Solvent extraction in the vegetable oil industry

THE vegetable oil industry in the Union has been revolutionised during the past two years by the installation of modern solvent-extraction equipment which eliminates partially or completely the conventional methods of oil expression with hydraulic or continuous screw presses. The combined capacity of the six new plants already operating is more than 300 tons/day of oil seed. The largest plants, which operate on a fully continuous basis, are situated along the Reef within easy reach of the Transvaal and Free State groundnut and sunflower farming areas.

Application of modern chemical engineering techniques to vegetable oil processing has resulted in big increases in the yields of oil obtained, as, by using solvent extraction, a residual oil content of less than 1% can be achieved in the oil cake as compared with 5 to 10% by former methods. The extraction solvent used is a petroleum fraction of suitable boiling range and efficient refrigerated recovery systems ensure minimum solvent loss.

The major plants now operating in the Transvaal fall into three main types. These are, respectively, the continuous horizontal extractors working on the Belgian de Smet system, the continuous vertical extractors supplied by the V. D. Anderson Co., of the U.S.A., and, finally, semi-continuous rotary horizontal extractors constructed by a Johannesburg firm of chemical engineers. A noteworthy feature of the de Smet plants is the self-filtering action of the extractors in which a continuous conveyor system moves the charge slowly forward while it is sprayed with solvent which has to percolate through a bed of material more than 3-ft. thick. It is claimed that elaborate seed preparation and flaking is thus eliminated, a rough crushing being sufficient.

The Anderson extractors operate on a counter-current principle whereby prepared oil-seed flakes pass down through a vertical column against a rising stream of solvent, thus being continuously washed free of oil. These plants are so designed that they stand

in the open air, thus achieving a big saving in building costs.

A smaller plant of German design and construction is operating at Maitland near Cape Town. This consists of a battery of stationary batch extraction vessels capable of processing a charge of about 30 tons/day. British competition in this important chemical engineering field has so far been unsuccessful, the only plant in operation of British design and supply being an experimental unit at Simonstown of very small capacity.

In view of the rapid industrial expansion taking place in the Union, it is probable that further plant capacity will be required in this field, where the capital investment in extractors and auxiliary equipment already exceeds half a million pounds sterling.

## Electrolytic chlorine

New electrolytic plants for chlorine and caustic soda production are at present reaching the operational stage at Umboqintwini and Pretoria. The large plant in Natal has been installed by African Explosives & Chemical Industries Ltd. and will supply the demand for chlorine created by the new paper and rayon factories in the Umkomaas district. South Africa is already producing a range of chlorinated compounds, including insecticides such as DDT and BHC. Plastics such as PVC will soon be added to the list when the additional chlorine becomes available at the Natal factory.

The Pretoria plant has been primarily installed to supply chlorine for water treatment at the power station to ensure efficient condenser operation. It is of particular interest, as it incorporates a new British design of mercury cell. Working on a purified brine, the cells are of rubber-lined steel with graphite anodes and special cathodes permanently immersed in mercury. These cathodes are steel-clad copper tubes which can also be used for temperature control in the cells.

A standard cell of the new design is claimed to yield up to 10½ lb./hr. of chlorine, together with caustic soda liquor of about 40% concentration containing up to 12 lb. NaOH. The current strength is normally 3,000 to 4,000 amp.

## Stearic acid substitutes

Plant for the manufacture of stearic acid substitutes from tallow and marine oils is now in full operation at a Simonstown factory in the Cape Peninsula. Stearic acid was previously imported into the Union, especially by the rubber and chemical industries, but the new South African product has proved very successful in replacing the overseas commodity, which was often found to be of variable quality. Several grades of stearic substitute are made to meet the specifications of various consumers with regard to colour, titre and purity.

The process consists of refining the raw materials, followed by hydrogenation with a nickel catalyst. Hydrogen is prepared in a battery of 70 Knowles electrolytic cells. The hard fats are then transferred to a splitting autoclave where they are converted into fatty acids, using high-pressure steam and an alkaline catalyst.

The autoclave, which can handle batches of several tons, is constructed of stainless steel and operates at a pressure of 150 p.s.i. It is of interest that this vessel was fabricated by a Johannesburg firm of chemical engineers, illustrating the progress already made in South Africa in the design and construction of large stainless-steel pressure plant.

The fatty acid stock is subsequently separated and, after further treatment to remove catalyst, the solid products are prepared in the form of flakes, using a chilled flaking roll. By-product glycerine liquor is purified and evaporated in a vacuum evaporator. The concentrated crude glycerine is then marketed to other firms for final distillation.

## Cobalt and tungsten plant

The new plant, installed at Springs in the Transvaal by Hard Metals Ltd., for the production of tungstic acid recently came into operation and is now functioning efficiently. Other new equipment in the factory reclaims tungsten metal from used drill tips returned by the gold and coal mining industries of the Union.

The company, which has an issued capital of £1 million, manufactures tungsten carbide tips for use in drill

stems, coal-cutter bits and dies for wire drawing. Cobalt metal powder is also produced for use in the manufacture of hard steel alloys.

As suitable minerals are not at present mined in South Africa, raw materials used by the company are purchased in the form of metallic concentrates from the Rhodesias. Cobalt concentrates containing about 40% Co are obtained as by-product alloys and slimes during the manufacture of electrolytic copper and cobalt at the Nkana refinery in Northern Rhodesia. Tungsten concentrates are chiefly mined in Southern Rhodesia.

The 1954 production figures of the Rhodesian mining industries illustrate the growing importance of cobalt and tungsten in the economy of the country:

	Short tons	Estimated value £
Electrolytic cobalt ..	588	1,383,218
Cobalt alloys ..	1,064	965,206
Tungsten concentrates	259	166,201

The activities of Hard Metals Ltd. are controlled by the Anglo American Corporation of South Africa Ltd. and are primarily directed at supplying the various mining interests of the group with vital equipment.

## Phosphoric Acid Manufacture by the Anhydrite Method

THE anhydrite method of making strong phosphoric acid, which has been tried out on the large scale in Italy, is reported to have given very satisfactory results. It is stated that the concentration is high enough to permit the acid to be used for the manufacture of concentrated superphosphate without previous evaporation.

The plant, which went into production in the spring of 1953, is built for a maximum capacity of 15 tons/day of  $P_2O_5$ . The primary materials are sulphuric acid (75 to 82%  $H_2SO_4$ ) and phosphate rock, ground to a fineness of about 95% through screen DIN40. The plant can be divided into two distinct parts—the feeding section together with the vessels for the precipitation of anhydrite, and the filtering section where the sludge is washed.

In the anhydrite process, the precipitation is carried out in such a way that the crystals will be formed as filterable anhydrite under controlled conditions. This is done by adding heat and by following a special sequence during the precipitation.

It is stated that cleaning and corrosion problems are not nearly so evident as in other types of phosphoric acid plants. In addition, the heat which has to be supplied to the Italian plant costs nothing, as the waste heat from the cooling air from the pyrites burners of the sulphuric acid plant can be used.

The development of the anhydrite method, the design and operation of the full-scale plant and the experience that has been gained, were discussed in a paper presented to the Fertiliser Society in London by S. Nordengren, I. Francia and R. Nordengren. The plant was planned and designed by the Swedish firm of Nordengren &

Co. A.B. and built by the Prodotti Chemici Superfosfati S.A., Vercelli, Italy.

The high temperature of the reaction makes the yield high and the reaction rapid. Filtration experiments have shown that about 98% of the water-soluble  $P_2O_5$  can be washed out of the sludge on a tray belt filter with a concentration of the first filtrate of 43 to 45% of  $P_2O_5$ . The residual 2% is naturally in solution in the moisture of the cake, calculated to be about 40% of the dry weight of the cake. Centrifuging of the cake may extract about two-thirds of this moisture with its  $P_2O_5$  content, which can then be returned to the process. This would make the total yield exceeding 97%, a figure which cannot be reached in the dihydrate process. The very high filtering speed attained by the intermittent reactor process makes the filter area small and the filter relatively cheap.

Also, it is stated, the short time of reaction makes the digesters small. The space taken up by an anhydrite plant will only be about half of the space required by a dihydrate plant with the same output of  $P_2O_5$ .

The detailed knowledge of how to produce strong phosphoric acid according to the anhydrite method would undoubtedly have found an industrial application at an earlier date but for certain technical difficulties. Available types of filters were not suitable for the separation of the calcium sulphate and, further, there was no filter cloth that could withstand strong phosphoric acid. However, several years ago a new filter, the Nordengren tray belt filter, became available. At the same time, plastics filter cloths came into the market.

## Recent Publications

**Surface-coating resins.** A 52-page publication, prepared jointly by the Surface Coating Resin Section of the British Plastics Federation and the Surface Coating Synthetic Resin Manufacturers Association, gives, in 14 tables, the basic information on all the British-made surface-coating resins at present available to the paint, printing ink and allied trades.

**Hydraulic pumps.** A range of hydraulic pumps is described and illustrated in a brochure from the Plessey Co. Ltd. The range consists of 98 different pumps which have a capacity range from 0.27 up to 42 gal./min., and are assembled for either direction of rotation with three alternative arrangements of drive shaft and 25 different porting arrangements.

**Insulation tapes.** A leaflet from Dunlop Rubber Co. deals with the availability, advantages and application of the Dunlop silicone-rubber glass-cloth tapes. These tapes are produced by coating a glass fabric of high tensile strength with silicone rubber. The leaflet includes technical data and photographs showing the application of the tapes.

**Leda chemical products.** The description, formula, constitution, specific gravity and various other data, including applications, of chemicals supplied by them are given in a looseleaf book issued by Leda Chemicals Ltd. There are four sections covering quaternaries, alkyl chlorides, anhydrous HCl solutions, and rubber chemicals.

**Idler rollers.** Of 4-in.-diameter tubular steel, supported on 1-in. ball bearings, in die-cast alloy housings with double labyrinth, pressure packed with grease, are featured in an illustrated pamphlet from British Jeffrey-Diamond Ltd.

**Aluminium production.** A handsome, 75-page illustrated booklet from the British Aluminium Co. Ltd. outlines the history of the company and its subsidiaries. The story opens with a brief outline of the early work by Sir Humphry Davy and others, through the Deville chemical process, to the discovery in the 1880s of the basic methods used today. Then follows the history of the British Aluminium Co. and its early struggles to find uses for a virtually unknown metal, the development of the strong alloys, the phenomenal expansions of output which took place during two world wars and the development of the peace-time uses which now make aluminium a leading industrial metal.

# Towards Better Use of LOW-GRADE ORES

O.E.E.C. EXPERTS SURVEY THE PROBLEMS IN EUROPE

THE task of the mission was to examine the facilities available for research, and the practical results achieved, in the mining of low-grade ores in certain European countries. It was to make a point of visiting workings mining low-grade ores under the most unfavourable economic conditions and establishing direct and permanent contact between its own members and research workers in the countries visited.

Between April 20 and May 21, 1953, the mission travelled through Britain, Sweden, Germany, Italy and France, visiting university and industrial laboratories and pilot plants, ore dressing plants at mines and smelters. It was, however, only in Germany that any manufacturing plants were seen. In order to fulfil the last of their terms of reference a symposium was arranged in each of the countries visited, at which the members of the mission had an opportunity of discussing with local experts the ore-dressing and related problems of the country in question.

The mission was composed of 24 experts drawn from 10 European countries and the United States.

## Economic aspects

The problem of low-grade ores is as much an economic as a technical one. In discussing the first aspect, the report suggests a limited definition for low-grade ores and emphasises the importance of the term 'cut-off grade' as a fundamental concept as well as a useful yardstick in economic geology and ore beneficiation. The mission's study was limited to questions connected with lowering the cut-off grade, i.e. making poorer deposits economically workable, in so far as this can be achieved by advances in mineral-dressing science and technology. Granted that this represents an attack on the problem on a limited scale, it should be remembered that it is one which is the most universally applicable and therefore probably the most important.

Every efficiently run mine should endeavour from time to time to determine and review its cut-off grade. In many recent instances a mine has, by lowering its cut-off grade, changed a small and extremely profitable deposit to a large low-grade deposit. For

A better understanding of the laws of comminution; a thorough grasp of the operation of cyclones; more study of dense-medium separation plant and of the possibility of applying control devices to gravity separation plant; a great deal of further research, both fundamental and applied, in the field of electrostatic separation—these are some of the needs that are stressed by a team of experts on the mining and dressing of low-grade ores, who have recently studied European progress in this field. The Organisation for European Economic Co-operation initiated this work, and the team visited a number of plants and laboratories and also discussed technical and other problems between themselves and with other experts. The outcome of all this is one of the O.E.E.C.'s excellent reports<sup>\*</sup> which, besides discussing the broad problems, also contains a wealth of detailed information about some of the latest techniques. This article, based on parts of the report, is mainly confined to the broader observations and recommendations of the team.

example, before selective flotation was introduced, many sulphide deposits which today rank as large ore bodies were mined as a small-scale operation exploiting only the richest part of the ore.

It is clear, therefore, that, by lowering the cut-off grade so that poorer ores could be profitably mined, the world's known mineral resources could be considerably expanded. To achieve this by means of technical progress should be the object of every engineer and research worker engaged in mining and mineral dressing.

While the relation between prospecting costs, mining costs and overheads per ton of ore remain more or less constant, the costs represented by milling (ore dressing) directly determine the earnings from a deposit. Consequently, ore dressing occupies a special position in the economics of low-grade ores.

It should be noted that the most striking technical developments have often occurred at mines which, originally engaged in mining and dressing rich ores, were subsequently compelled to base their activity on increasingly low-grade ores. The smaller profit margin which obtains in working low-grade deposits compels companies to introduce large-scale operations

using the most up-to-date methods.

An analysis of milling cost indicates that comminution is a relatively expensive process, and the report discusses this question in some detail. The importance of research in comminution is likely to grow, since it is suggested that the most important key to Europe's metal supplies is to be found in the further development of complex, generally fine-grain deposits. Concentration of this type of ore will also need better means of size analysis and classification in the subsieve range; moreover, the physical chemist has a great opportunity to develop new methods of recovery. Finely divided minerals will bring new problems not only to ore dressers but also to the smelters, since they will have to deal with increasing amounts of fine concentrates. Flash roasting, fluosolids, pelletising and sintering are examples of the way in which these problems are being tackled at present. The report is emphatic on the need to improve co-operation on a technical basis between mill and smelter.

A survey of the research facilities in the countries visited by the mission indicates that pilot-scale facilities are generally inadequate. Three important centres of mineral-dressing research and training were visited, i.e. the Royal School of Mines, London; the Royal Institute of Technology, Stockholm; and the Clausthal-Zeller-

\* 'The Mining and Dressing of Low-Grade Ores in Europe,' O.E.E.C., Paris, 1955. 320 pp., illustrated, 18s.

feld School of Mines, Germany. Following a discussion of the different approaches to the training of ore-dressing engineers in the various countries, the report makes a plea for raising their status to attract more men to this profession. To ensure complete extraction and purer concentrates from the complex low-grade ores of the future, it will be essential to have more highly qualified supervision. The mission sees a growing tendency to centralise treatment in large plants for the concentration of a number of ores from different mines within one area. Such plants will have to be staffed by highly qualified men, backed by adequate research and pilot-plant development facilities.

#### Technical progress

The report contains a survey of interesting developments in research and practical working which came to the mission's notice. The mission's observations may be summarised under various headings as follows:

**Comminution.** A better understanding of the laws of comminution would help to improve the efficiency of every mineral-dressing plant. The work being carried on in this field in the mineral-dressing laboratory of the Royal Institute of Technology, Stockholm, is therefore of the greatest interest. With some extensions and modifications, for which plans are in hand, this will undoubtedly become one of the foremost research and testing laboratories in this field in Europe.

In treating marginal ores, it is especially important to keep the costs of crushing and grinding as low as possible. Any improvement in this direction can materially affect the economics of exploiting the deposit.

To obtain the best results, comminution and classification should be so contrived as to yield a particle-size distribution corresponding to the optimum sizes for the dressing method to be used. This is particularly true of finely disseminated ores in which the minerals have to be liberated by fine grinding with low slime production.

**Hydrocyclones.** At the Atomic Energy Research Establishment at Harwell, a systematic study has been undertaken of the various factors affecting the operation of a conventional cyclone. These tests have been carried out in a laboratory cyclone built of interchangeable units of colourless, transparent plastics, so that it is possible to study the movements of water and solid particles and to record them on film. The mission agreed that such fundamental studies

on cyclones are of vital interest in extending the field of application of this type of apparatus.

The following firms are carrying out work on cyclones at the pilot-scale or practical stage: Stripa Gruv A.B., Sweden; Wedag and also Humboldt, Germany; Minerais et Metaux, France; and Stamicarbon, Holland. In 1948-49, Stripa Gruv developed a 'double cyclone,' the cylindrical part of which tapers off into a cone at each end.

The use of the cyclone is still entirely based on empirical rules. The people working with cyclones whom the mission was able to question usually knew nothing of the way in which their apparatus worked, the characteristic curve of its operation or the underflow and overflow distribution between the different size ranges.

**Dense-medium separation.** The use of static dense-medium separation might reduce the amount of fine tailings as compared with those from a jig plant and the introduction of dense-medium cyclones would close a serious gap between the static dense-medium plants and flotation plants. The main object should be to eliminate tailings at an early stage and thus relieve the subsequent installations.

The mission is convinced that more work needs to be done on the effects of size distribution in substances used as dense media in either type of plant.

**Other gravity separation methods.** True vanners have been doing useful work for some 50 years. Their advantage for gravity separation of fines lies in their continuous operation. At the Geevor Tin Mines Ltd., Cornwall, true vanners were seen giving a recovery of 55½% for grains below 200 mesh, with a high degree of concentration and continuous working. More experiments should be carried out on true vanners, says the team.

For treating slimes, the addition of dispersion agents will certainly become more common in future. Experiments in the addition of both dispersion and wetting agents and their influence on the utilisation of shaking and tilting tables would be of great interest. Better control of the amount of feed to each machine and control of the pulp density are also important. A more intensive study should be made of the possibility of applying control devices, such as are used in flotation, to gravity separation processes.

**Flotation of oxides and oxidised materials.** The report summarises developments where the flotation of minerals other than oxides of lead,

copper and zinc are concerned. Of the minerals mentioned, flotation on an industrial scale has been applied only to phosphates of lime, graphite, fluorite, autunite, parsonsite, felspar, mica and ilmenite. For all these, fatty acids are used. Several patents have been taken out for the flotation of bauxite, particularly in the United States, but as far as is known that has not been applied industrially.

Although much progress has been made in the last few years, the problem of floating oxides or oxidised ores is by no means solved. Even where the process has been applied industrially, there are many difficulties still to be overcome, such as the deleterious effect of slimes and clay. This indicates that particular attention should be paid to the study of pretreatment and conditioning before flotation. For slightly oxidised minerals, further development work might be done on 'attrition machines' such as those installed at Pebble Beach, California. They resemble flotation cells in which the particles are rubbed and brushed without breaking the grains.

The successful flotation on an industrial scale of many important minerals in this field is an indication of the progress that might be achieved by systematic laboratory research followed by pilot-scale work. It should be emphasised that this study must be concerned with the fundamental phenomena of flotation and will therefore be chemical and physio-chemical in nature. An effective combination of chemical and mechanical conditions in the flotation machines should be aimed at.

**Flotation of sulphides.** There is a growing tendency to centralise treatment in large plants for the concentration of a number of ores from different mines within one area. It is easy enough in a small plant to extract the main metallic component of a complex ore by selective flotation, but bigger units and more highly qualified supervision are required to ensure that complete extraction and purer concentrates are obtained. It is cheaper in the long run to build these plants on a large scale and to situate them in the centre of the ore deposits of a whole area.

**Magnetic and electrostatic separation.** Among the more recent developments in magnetic separation is a drum separator with zig-zag pole arrangement designed by Wedag. In this separator, with a fixed magnetic system and a rotating drum of non-magnetic material, the magnetic pole edges are arranged in such a way that

during operation the magnetic fields show a zig-zag form. This results in a high capacity and a winnowing action on the drum surface, whereby non-magnetic particles can easily be separated.

To deal with low-grade, weakly magnetic ores, the Studiengesellschaft für Doggererz has developed a machine not unlike the American *Carpo* machine which has been in use for many years in Jacksonville, Florida. The principle is that a large electromagnet with two overhanging pole pieces is positioned so as to produce an intense magnetic field (up to 16,000 to 18,000 gauss) on two horizontal soft-iron rollers placed one at each end of the machine.

In electrostatic separation, manufacturers are mainly concerned at present with practical day-to-day problems. Further development is likely to depend on fundamental research in the physics and physical chemistry involved.

**Problem of finely divided minerals.** In a particular instance quoted, namely the gravimetric treatment of fine wolfram ore, research suggest that it might be useful to deslime the pulp at approximately 10 microns (quartz) before feeding it to the first concentration appliance.

The flotation example quoted shows that in this range decreasing grain size in the concentrate is accompanied by a marked diminution in the valuable contents. This observation, coupled with the fact that in selling minerals there is a limiting content value below which a mineral is penalised by the buyer, suggests that desliming of the pulp before flotation might well mean an increase in the value of these concentrates, despite a lowering of the overall recovery figure.

Minerals of 10-micron size or smaller usually flocculate to a considerable extent in ordinary grades of water and any separative treatment demands dispersion as the first preparative step. Attempts at flotation should be preceded by dispersion of the material before other reagents are added, not coincidentally with them. Recently, selective flocculation of phosphate rock from slimes that were previously dispersed has yielded a 10% overall increase in recovery. As a result there is a new wave of research on phosphate slimes.

#### Conclusions on primary separation

At the present time, dense-medium separation is unquestionably the most widespread and, thanks to the cyclone,

the most promising process, though all the techniques mentioned are worth considering and none should be rejected out of hand.

One of the greatest practical difficulties arises from the fact that reliable test results can be obtained only from large quantities of crude ore, owing to the obvious drawbacks of using sampling methods with coarse materials. This makes it very difficult to carry out laboratory tests, and the ideal method would seem to be the pilot plant, still a rarity in Europe.

#### Tailings disposal

The mission makes various recommendations concerning this problem and also considers the question of disposing of used mine waters. In most O.E.E.C. countries, indeed, the problem of used-water disposal is often more troublesome than that of the residues. The mission urges that the severity of the existing legislation in many countries concerning the disposal of used waters be reviewed, as it may prevent the exploitation of large low-grade deposits. At the same time, more research should be carried out on the deleterious effects of such waters on fresh-water flora and fauna. This might be followed by a study of processes for the inexpensive treatment of used waters.

#### The mission's recommendations

The mission recommends the setting up of national and inter-

national organisations to encourage, advise on, document and give information on research in ore beneficiation. International congresses should be organised at regular intervals.

Long-term examination of low-grade deposits in the various countries should be carried out and wider facilities should be provided for research and development. It is especially important to establish more pilot plants, either centrally or in the large mineral-bearing areas. Where such pilot plants are not actually combined with university laboratories, it is vital that the closest relations be maintained with the latter, so that fundamental research and development shall not be entirely separated.

More material on low-grade ores should be published in recognised journals. Private firms and research institutes are urged to permit, to the widest possible extent, publication of the results of their research and development work.

The status of ore-dressing engineers and research workers should be raised in order to attract first-class men and more training facilities in mineral beneficiation should be provided.

Finally, everything possible should be done to improve co-operation between mill and smelter.

### Newspaper from Hemp Hards in Rumania

Recently two chemists, V. Alexa and M. Alexa, working at the Laboratory of Chemical Technology of the University of Cluj (formerly Klausenburg), have investigated the possibilities of making a paper of superior quality from hemp hards, which are rich in cellulose. Although there is only one species of hemp, this varies very much according to the conditions under which it is grown. Therefore, experiments were made with the hards from a great number of Rumanian hemp districts.

The hards were subjected to the 'soda process' of pulp making in autoclaves of 25-litres capacity heated indirectly by superheated steam. The concentration of the caustic soda solution was varied between 3 and 5½%, and in some experiments the caustic soda was partly replaced by sodium sulphide. The pressure was varied between 4½ and 6 atm. and the dura-

tion of heating between 5 and 6 hr. The cellulose obtained in each case was analysed to find the percentage of  $\alpha$  cellulose.

In the most successful experiments the cellulose contained between 90 and 93% of the  $\alpha$  modification. In another series of experiments the hards were pulped to make 'half stuff,' which was then tested for its mechanical properties.

The investigations have shown that it is possible to make from hemp hards a paper which is suitable as newsprint. The quality varies according to the provenance of the hards and the method used for pulp making. A paper of the same quality as that made from rags, however, cannot be made from the hards (mainly stems), but only from the fibres prepared for spinning. The experiments have been described in *Studii si Cercetari Stiințifice*, 1954, 5 (3-4), 157.

# Harwell's Atomic Energy Work

## SOME RECENT ACHIEVEMENTS REVEALED

*A new report\* takes the story of the Atomic Energy Research Establishment, Harwell, from the point at which it was left in the 1952 report ('Harwell—The British Atomic Energy Research Establishment, 1946-51') up to the formation of the United Kingdom Atomic Energy Authority in August 1954. Changes in international agreements on release of information have made it possible to publish details of research work hitherto treated as secret. This new report is divided into two parts, the first treating of the major programmes of the Establishment, primarily for non-technical readers, and the second dealing with selected research work for scientific readers who have not specialised in the fields discussed. The author, K. E. B. Jay, handles both these formidable tasks with admirable skill and crystallises the accomplishments of and current trends at Harwell for scientist and layman alike. This review is concerned with only some of the parts of this report that are of interest to chemists, chemical engineers, metallurgists and others.*

### Production programme advances

UNTIL recently one of the main jobs of the Atomic Energy Research Establishment at Harwell has been to furnish the production side of the atomic energy organisation at Risley with the scientific information that it needed to design its factories. During the last few years a large Research and Development Branch has been set up within the Industrial Group to do much of the applied research needed for factory design and operation; Harwell's primary role is now to carry out long-term research and to act as a source of ideas for reactors and processes, though a considerable amount of development is still done.

The earlier work done for the Industrial Group is known at Harwell as the production programme. Changes in the classification of hitherto secret work have made it possible to report more fully on this programme than was permissible hitherto and some interesting advances are reported, briefly and in simple terms, in the

first chapter of the new report. Thus, it is recorded that in the early stages of the development of the Windscale piles there was some debate about the best method of cooling them; water and high-pressure gas were suggested, but it was pointed out that efficient cooling by air at atmospheric pressure would be possible if the effective area of the cans surrounding the uranium rods was extended by fins, and that by adopting this idea the design and construction of the piles would be simplified. Calculation showed that fitting fins would not cause an unacceptable increase in the capacity of the cans to absorb neutrons, but experiment was necessary to establish whether or not the cooling efficiency could be increased sufficiently.

Accordingly a full-sized model of one of the uranium channels proposed for the pile was set up at Harwell and measurements were made of the efficiency with which heat was transferred from different kinds of fin when cooling air was blown down the channel at various speeds. These experiments showed that the design originally proposed was not satisfactory and enabled an efficient modification to be evolved. The experiments also showed the importance of good thermal contact between the uranium inside the can and the walls of the can itself, so that the heat could pass readily to the can and fins. A test to ensure that this contact has been achieved was evolved.

Although superficially simple, the diffusion plant at Capenhurst has nevertheless presented many difficulties in design, nearly all of which have arisen from the corrosive nature of the gas used. Uranium being a metal, to separate its constituent isotopes by gaseous diffusion a compound must be found which is gaseous at reasonable operating temperatures. Only one compound is practicable and that is uranium hexafluoride. This is, however, nasty stuff to use in a plant. It reacts chemically with nearly all metals, it combines rapidly with water to form solid compounds which would block the small pores in the membranes and it is gaseous only at temperatures greater than about 100°F. The last two facts mean that the plant must be virtually vacuum-tight in order to exclude atmospheric air, which would inevitably be at least a

little moist, and that the stages must be kept at an ambient temperature around 110 to 120°F.

As the gas is so corrosive it has been necessary to devise ways of driving compressors from electric motors without allowing the latter to come into contact with the gas. Several novel methods of achieving these ends have been developed at Harwell and brought to a high degree of perfection at the Industrial Group's laboratories at Capenhurst. The separation efficiencies have also been measured for different kinds of membrane working in hexafluoride. Measurements of this kind are usually done with non-corrosive gases and the experiments in hexafluoride were complicated and tedious. Other work done at Harwell for the diffusion plant has included theoretical studies, development of mass spectrometers and chemical studies.

### Reactor development and chemical engineering problems

Discussing advances in the reactor programme at Harwell, the report points out the three main considerations in the design of a nuclear reactor. One of these—that of keeping the reactor going—is concerned with the stability of the fuel rods or elements under irradiation and heat stress, and with the removal of by-products that would otherwise destroy the neutron balance. It therefore involves principally the metallurgist, the chemist and the chemical engineer.

The spent fuel will invariably contain some unburnt fissile atoms, as well as fission products. The fissile atoms can be recovered by chemical treatment, but the sort of treatment likely to be economic depends on several considerations. Thus it may be unnecessary actually to remove the unburnt fissile material; it may be suffice to reduce the amount of strongly absorbing fission products, the so-called pile poisons, and then fabricate the material again into fuel elements. Some of the stages in the fabrication of metals result automatically in some degree of purification, for example reducing metallic compounds to metal and re-melting metal billets for casting into rods. Working along these lines the chemists and chemical engineers are studying chemico-metallurgical methods of treating fuel elements

\*'Atomic Energy Research at Harwell' by K. E. B. Jay. Printed for the United Kingdom Atomic Energy Authority by Butterworths Scientific Publications. 156 pp., illustrated, 5s.

†H.M.S.O., 1952.

which aim to remove only the principal poisons and to keep the uranium in metallic form throughout. These methods include melting the fuels and skimming impurities from the melt, electrolysing the fuels at high temperature in fused salts, and dissolving the wanted metal in other molten metals also at high temperature.

With some fuels (especially natural or slightly enriched uranium) it may be desirable to separate the plutonium from the uranium in which it is formed; if this must be done then it is essential that the separation and recovery of the plutonium should be complete. If, on the other hand, the reactor is one in which it is permissible for the plutonium to be left in the treated fuel elements, it is vital that the chemical treatment to remove poisons should not separate the plutonium from the uranium at all.

The methods just outlined are in an early stage of development. There remain formidable chemical engineering problems to be solved, for example in conducting by remote control highly radioactive operations at high temperatures, and in fabricating still active fuel elements. The successful solution of all the problems would result in a process that should be cheaper than the solvent-extraction used at Windscale while still giving a product which would be entirely satisfactory for use in power reactors.

#### Application of isotopes

The A.E.R.E. has for some years run an industrial advisory service, the duty of which is to advise enquirers from industry on the best way to use radio-isotopes to solve their particular problems or even, in some circumstances, to perform experiments for the enquirer, either in his own works or in the laboratory at Harwell. The demands made upon this section have grown steadily so that now 600 to 800 enquiries are received in a year from all over the world. The report discusses some interesting developments that have come about through these enquiries; such as an instrument for measuring the thickness of a pipe or plate. Another development concerns a common industrial operation—that of mixing, where the proportion of one of the ingredients is very small indeed and yet it must be evenly distributed throughout a large mass of material.

#### Chemical processing of radioisotopes

The two pile-produced isotopes most commonly used therapeutically

by internal administration are phosphorus-32 and iodine-131. The demand for these has grown so much (it was nearly five times as great in 1954 as in 1950) that it was decided in 1954 to transfer to Amersham the chemical extraction of these isotopes from target materials irradiated in 'Bepo.' This decision provided an opportunity to develop and introduce new processes more suitable for routine operation, particularly in the protection against radiation which is provided. The production units for these and a number of similar isotopes are installed in a group of new buildings specially designed for the purpose.

#### New chemical engineering building

The Establishment is equipped with special laboratories for experiments with radioactive materials. The first of these, the radiochemical or hot laboratory building No. 220, was described in the last report. This has recently been extended by a new wing designed primarily for work on plutonium chemistry and metallurgy.

The second of the radioactive laboratories is the new chemical engineering building, completed since the last report. This building is designed for radioactive work on any scale up to pilot plant; it has in fact been used for small-scale production. It combines laboratories, plant and workshops in one building. The arrangement is very versatile: it is possible to build hot cells in lead or concrete wherever they are wanted and to remove them when the experiment is finished; galleries are provided for column experiments; services are available from ring mains round every floor level; and special arrangements are made for loading active effluent into tankers. The structure is a tall one; there are the equivalent of five stories, the last of which contains the ventilating plant. There are two floors of offices and laboratories for analytical work and for process development, but the main volume is not permanently subdivided by floors, though steel chequer-plate may be laid at any level to increase the total area, if desired.

#### Chemical engineering research

The chemical engineer has a number of interests in an establishment such as that at Harwell. One of particular importance is a project where new techniques are employed, or where old techniques are applied in new environments, as research to improve design methods.

The importance of solvent extraction methods, as in the separation of plutonium from irradiated uranium at Windscale, led the Chemical Engineering Division to undertake an extensive programme of research on this unit operation. After a review of the existing information it was concluded that there were two main lines on which effort should be concentrated: an investigation of the hydrodynamical problems involved and an investigation of the factors affecting the mass transfer of solutes across liquid/liquid interfaces. The investigations were, however, interdependent and the results show promise of being valuable outside as well as inside the atomic energy field.

#### Countercurrent extraction columns

The first step in the investigation was to study the behaviour of two liquids flowing countercurrent in a packed column. A series of experiments, initially in columns of 3-in. diameter and later in columns of up to 12-in. diameter, was made in which the size of the packing and the liquids used were varied. 'Flooding rates,' which determine the liquid-carrying capacity of the columns, and 'hold up,' the amount of the dispersed phase contained in the column, were of prime interest.

By combining the results of the hold-up and droplet-size investigations it was possible to derive a simple expression from which the approximate interfacial area of contact can be predicted.

The above work was carried out without the presence of a third component transferring from one phase to the other. The next stage was to investigate the effects of the presence of a third component and, in the first instance, organic solutes were used because their equilibrium was better understood. In general the results could be interpreted quite well on the basis of the expressions derived in the earlier work, but there were anomalies, particularly some in which the transfer rates were much higher than expected.

The work on packed columns has been extended to other types of extractors.

The whole series of investigations has enabled a unified picture to be built up of the hydrodynamic behaviour of a wide variety of extractors.

The work referred to above has dealt with the behaviour of the two phases in liquid/liquid extraction, but this is only part of the story. The extractor is used to transfer material in solution from one phase to the

other, for example uranyl nitrate from an aqueous solution into an organic solvent. The bulk phases are not necessarily at equilibrium, although it is usually assumed that equilibrium does exist at the interface. The chemical engineer is interested in the rate of transfer and the manner in which resistance to transfer is built up. Some work in this direction is briefly reviewed in the report.

### Physical chemistry

Most of the physical chemistry research at Harwell has been into the nature of the phenomena useful in separation processes, particularly processes that can be used in columns. In principle these processes may be divided into three categories, involving equilibria between one solid and one fluid (gaseous or liquid) phase, two liquid phases, and one liquid and one gaseous phase. In practical applications the first category includes chromatographic and ion-exchange columns, the second solvent extraction columns and the third distillation columns.

In the second category, the importance to atomic energy work of solvent

extraction has led to detailed studies of the chemical mechanism involved in the equilibria of electrolytes between aqueous and organic solutions.

It has been found that solvent extraction methods can be applied successfully to elucidate the activity coefficients of mixed concentrated electrolytes. For organic solvents containing groups with very strong electron-donor properties it is often desirable, in order to facilitate back extraction, to reduce the extraction power by dilution with neutral solvents (such as carbon tetrachloride or paraffins). Such diluents reduce the extraction coefficients much more than proportionately to their mole fractions. These effects are now well understood and are connected with the number of solvent molecules required for the solvate of the particular electrolyte. This knowledge has furnished a powerful tool for investigating the composition of such solvation complexes.

Altogether the study of these extraction processes has greatly stimulated research into the thermodynamics of multi-component systems, which in its turn has improved understanding of the observed equilibrium relationships.

important differences between rectangular troughed and tubular natural-frequency-vibrating conveyors is that the rectangular units require less head room than the tubular type.

The long tubular natural-frequency conveyors handling the pure wollastonite coming from the magnetic separators deliver it to elevators which discharge into three 20-mesh storage tanks. From these the material goes by chute and feeder to one of two conical pebble mills, and the finished product travels by air slide and elevator to one of six 150-ton finished product bins.

The plant, described in *Mechanical Handling* recently, also includes some interesting bag-filling and handling features.

### Hard Metals

A British translation of the major part of the 'Handbuch der Hartmetalle' has been published.\* Three firms shared the task of translation: Hard Metal Tools Ltd., Metropolitan Vickers Electrical Co. Ltd. and Murex Ltd. A certain amount of condensation was necessary, but this was achieved without detracting from its value by removing information already well known or previously published in English.

The handbook deals with three principal classes of hard metals, *viz.* sintered alloys of hard carbides to which small amounts of metals have been added, alloys with a tungsten carbide base and hard facing alloys applied by gas or electrical welding to a hard carbide base. The publication opens with a general survey of the subject and of the physical properties of hard metals and their metallurgy. It goes on to deal fully with the scientific principles of the sintering technique as far as they apply to the production of hard metal.

In the section of the book dealing with production the organisation of the factory and the works supervision of hard metal production are dealt with and the methods of mixing, milling, sintering and shaping the product are described in detail. The text is supported by diagrams, tables, photographs and photomicrographs.

The appendix consists of the author's comments on an American paper entitled 'The Role of the Binder Phase in Cemented Tungsten Carbide-Cobalt Alloys,' by Gurland and Norton.

\*A Handbook of Hard Metals, by W. Dawihl. Published by H.M.S.O. for D.S.I.R., price 25s.

### Mechanical Handling of Wollastonite

A NEW American plant for the processing of wollastonite—which is ground and sold for use in the paint, ceramics, plastics and other industries—makes use of a considerable amount of mechanical handling plant. The wollastonite, which is mined 1½ miles from the plant, is in crystalline form and carries some valuable by-product garnet which is recovered by magnetic separation and sold for polishing rouge and abrasive products.

The plant has been erected by the Cabot Minerals Division of the Cabot Carbon Co. at Willsboro, New York; the output capacity is 60,000 tons p.a. and this may be increased as required. In the first stage, ore arrives in lumps about 18 in. in size, is crushed to 2 in. and passes via a belt conveyor to a transfer box. From there the ore passes—the route depending on whether it is wet, merely damp, or dry—through a system which includes an oil-fired drier, two screens and a gyratory crusher. Having been reduced to ½ in. or less, the material passes to one of three storage tanks.

The bottom of each of these three storage tanks is equipped with a *Syntron* feeder to a belt conveyor which carries the material to the third

elevator which discharges into a third screen. At this point there is another closed circuit permitting 20-mesh and smaller to pass through the screen and to carry the larger sizes by belt and vibrating conveyors to two-roll crushers which discharge by chute back to the third 20-mesh screen.

From the third screen the 20-mesh ore is delivered by a fourth elevator and rectangular natural-frequency conveyor to a series of four screens which discharge into four *Exolon* magnetic separators to remove the garnet. Reduction to 20 mesh makes complete separation possible. The garnet passes by chute to a surge bin from which it is discharged and trucked to storage. Waste from the separators goes to another surge bin.

There is a tunnel 100-ft. long under the four magnetic separators, in which there are two tubular natural-frequency conveyors 93-ft. long to handle pure wollastonite at the rate of 3 tons/hr. each which are said to be the longest of this type ever installed. Owing to the natural frequency of the conveyor springs, the power required for even such long units is supplied by two 1-h.p. motors for each. It might also be pointed out here that one of the

# Plant and Equipment

## Metal-sheathed carbon tubing

A new type of tubing for conveying corrosive liquids is, in effect, two tubes—an inner tube of carbon or graphite being protected by an outer tube of metal. This combination is claimed to provide both resistance to corrosion and high mechanical strength, and the tubing is commercially available together with special fittings that ensure continuity of carbon in the pipe.

The external metal might be carbon steel, alloy or stainless tubing, or some other material such as copper, brass, etc. Suitable applications for the tubing, according to the makers, include the conveyance of (a) hot chlorinated solvents, (b) hot hydrochloric acid and hot dilute hydrofluoric acid (up to 55 to 60%) and (c) corrosive solvents associated with the oil refinery industry.

Advantages claimed for this development are that the tube is safeguarded against breakage and that higher pressures and temperatures are possible, while both grades are resistant to alkali.

The new tubing, known as *Metica* tubing, has been developed by the Talbot Stead Tube Co. Ltd.

## Rubber accelerator

A new rubber accelerator, *Santocure MOR*, has been developed by Monsanto Chemicals Ltd. as an answer to the scorch problems arising from the higher temperatures and faster processing of tyre vulcanisation today—problems which the advent of super-abrasion furnace blacks may well tend to aggravate. Monsanto, with its emphasis on dustless forms of accelerator, has already developed a granulated form of this new product, which is expected to be available in the near future.

In a laboratory report issued by the company, *Santocure MOR* is compared with Monsanto's delayed-action accelerator *Santocure* for scorch characteristics and rate of cure at varying processing temperatures and at two different temperatures of cure. Data are brought forward to show that the new accelerator has enhanced processing safety.

Chemically, *Santocure MOR* is 2(4-morpholinylmercapto) and in appearance is a light buff powder. The following physical properties are given: specific gravity at 23°C., 1.41; melting point, not less than 79°C.;



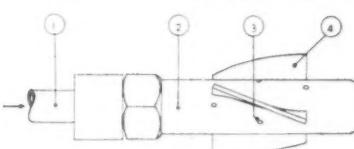
The new range of protection and control equipment of Teddington Industrial Equipment Ltd. includes the Spediflam burner watcher, which is available with built-in or separate flue thermostat, incorporates a patented circuit and switch mechanism and has many unique features. It is designed for all types of automatic oil burners (continuous or intermittent ignition), has a built-in transformer to provide a low-voltage control circuit, built-in lock-out indicator lamp and independent purge period adjustment. The control unit is designed to provide an instantaneous start and fails safe under all fault conditions, the makers state.

soluble in acetone, benzene, chloroform, carbon tetrachloride; insoluble in alcohol, water; sparingly soluble in ether.

## Examining interior surfaces

A device known as an *Endoscope* is claimed to permit the critical examination of interior surfaces where normal direct vision (or the use of mirrors) is impossible. Interior surfaces of chemical engineering plant, pressure bottles and vessels, rigid and flexible pressure pipes and tubes of all descriptions are given as examples.

In medical terminology an 'endoscope' is an apparatus designed for illuminating a cavity of the human body in order to observe its inside. Bodson *Endoscopes* are optical devices derived from the medical type, but which have been specially designed to inspect the interiors of inert hollow



The essential simplicity of the burner head referred to on this page is shown in this diagram. Numbered parts are: (1) oxygen inlet, (2) burner body, (3) radial ports and (4) radial blades.

bodies. They are equipped with an objective to register the image and with lenses for transmitting the image to the eye through an eye piece, as well as the electrical illuminating source. The entire optical system, as well as the electrical system, is mounted in a rigid tube of appropriate diameter and length, which is introduced into the cavity. The dimensions of the tube may vary considerably, according to the application, and a variety of combinations of diameter, length and type of objective head is available.

These devices are marketed in the United Kingdom by P. W. Allen & Co.

## Probe light for drums and barrels

A device quite different from that described above is a heavy-duty probe illuminator for examining the interior of drums and barrels, which has recently been introduced by Engineering Developments (England) Ltd. Mounted at the end of a tubular arm some 21-in. long (or longer if required) is a cylindrical lamp unit, 1½ in. in diameter. The 18-w. bulb is completely encased in a heat- and shock-proof glass shield protected by a wire cage; it is operated through a separate mains transformer unit.

A push-button switch incorporated in the finger-grip handle is a feature which, makers claim, not only gives the operator complete control but—by avoiding all chance of leaving the unit switched on for long periods—eliminates risk of overheating and so permits the use of a higher-wattage bulb than would otherwise be possible. It is stated that the light is sufficiently brilliant to illuminate fully the inside of containers even when coated with non-reflecting material.

## Cleaning out tubes

A new method of cleaning the insides of tubes is described in a report on maintenance work carried out recently at the Prince Regent Tar Co. The tubes involved in this particular job were still tubes used in the coal-tar distillation process. In service these tend to become fouled by deposits of bitumen and normally cleaning is a tedious job undertaken with a mechanical drill and scraper. In some cases it may take a full day to clear one tube.

It is stated that the new method reduced cleaning time from one day to 30 min. The apparatus was an adaptation of flame-cleaning equipment supplied by British Oxygen Co. Ltd. The still tubes in question were

cast iron, 15 ft. in length and of 2-in. bore, and a simple burner was designed with integral fins, which besides spacing the burner from the wall of the tube, acted to some extent as scrapers. The burner fitted into the bore so that the whole length of the tube could be traversed internally.

During earlier attempts to burn out the residue, too much heat was applied to the casting, but it was noted that at one stage of the proceedings the gummy bitumen turned into a form of powdery coke and that this material was easily removed by scraping. In view of this, the burner which was constructed had only a few  $\frac{1}{16}$ -in. holes drilled into it for gas nozzles and these were sufficient to bring about the required conditions. The assembly was attached to an ordinary piece of lance tubing through which the gases were supplied and it was then possible to push the assembly progressively through all the obstructions.

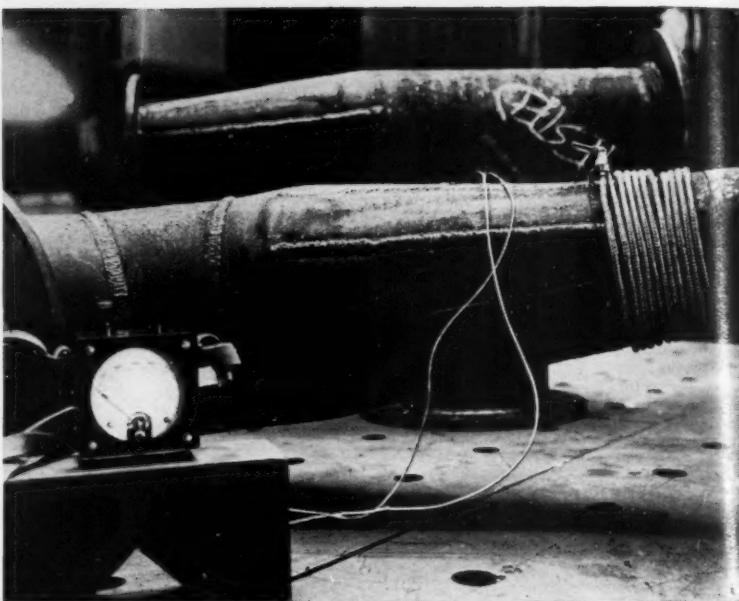
Alternate passes with this burner and a scraper proved adequate to remove all deposits, the report states.

Although no excess of heat is applied to the pipe being cleaned, the burner itself attains a red heat in a very short time and must, therefore, be constructed in stainless steel. It is also necessary to use a short length of stainless-steel tube between the burner and the lance pipe, otherwise their life is very short.

#### Automatic control of modulating oil burners

An arrangement of their *Unitrol* oil burner to produce a fully automatic oil-burning system suitable for all steam-raising plant and for some furnace and chemical plant was recently announced by White's Marine Engineering Co. Ltd. In this type of burner the oil and air controls are combined in one lever and there is a minimum turn-down ratio of 4:1. Once alight, the boiler output is controlled by altering the position of the single lever actuated by a small electric motor under the control of a potentiometric controller.

Both manually controlled and automatic *Unitrol* burners are manufactured in standard sizes varying in output from 3 to 45 gal./hr. normal maximum output. In each case this represents the output when all the air is supplied by the blower, i.e. the burner is not fitted with an air register. Under natural-draught conditions the output of the burner can be doubled by means of an air register, in which case only 50% of the air is supplied



This photo illustrates the use of new apparatus for preheating and stress relieving of welds.

by the blower. Under forced-, induced- or balanced-draught conditions, the output of the burner can be increased up to about four times its normal output by the same means and in these cases only about 25% of the air is supplied by the blower. In such arrangements the air register damper is interlocked with the burner lever so that the arrangement is still controlled by a single lever.

Thus, the makers state, it is possible

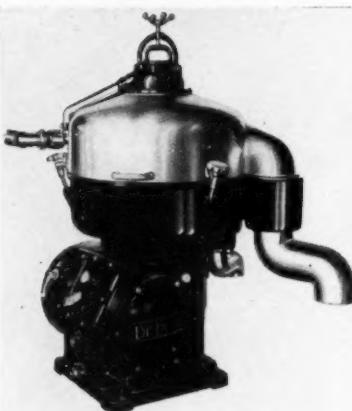
to use the burner for outputs as high as 180 gal./hr. under manual or automatic control, at the same time keeping the blower power well within accepted figures.

#### Preheating and stress relieving of welds with armoured heaters

With advances in welding techniques and the increased use of alloy steels, an efficient mobile method of preheating and stress relieving has become essential. This applies particularly to the construction of oil pipelines, high-pressure steam pipes, gas pipelines and installations in oil refineries, refrigeration plants, etc., and to the fabrication of vessels of all shapes and sizes. The use of furnaces is often impossible or uneconomical and heat treatment on the site presents a variety of problems.

An armoured heater is being marketed which, according to the makers, provides the high temperatures necessary for both operations. At the same time, they state, it enables the engineer to meet on the site the heat-treatment conditions required by the various alloy steels. This new heater, being flexible, can be wound round most pipes and vessels with ease and controlled heat can be applied. It can be operated from a welding generator or other suitable power source.

As an example of the heater's performance, the suppliers, Electro-



A new, large, continuous, three-way centrifugal nozzle separator, type QX210-00, is for the separation of solids from a liquid or two immiscible liquids. It is used for starch concentration, gluten stripping, fish-oil separation, etc. The suppliers, the Alfa-Laval Co. Ltd., state that machines of this type, with throughputs of up to 20 gal./hr., can be used for effluent treatment, etc.

thermal Engineering Ltd., cite the case of a heater applied to a 9-in.-diameter steel-alloy pipe with a wall thickness of  $\frac{1}{8}$  in., raising the temperature from an ambient of 12°C. to 700°C. in 45 min. Asbestos tape (2-in.) lagging was employed.

### Valve control and lubrication

As plants grow in complexity, remote control of valves is becoming increasingly important. At the Engineering, Marine and Welding Exhibition in London this month the Audley Engineering Co. Ltd. are demonstrating the application of remote control to valves in five individual ways. That of the photo-electrical cell is of particular interest; the removal of a catalogue from a slot ensures the operation of the valve and, in addition, there is foot, electric and manual control.

In a demonstration of valve lubrication, the effect is shown of *Lubecoat* treatment of the valve surfaces in conjunction with a lubricant having film strength which will not break down under high pressures. It is claimed that the *Lubecoat* process makes the valve surfaces more capable of retaining lubricant and that it has, of itself, a very low coefficient of friction so that the operational effort of a valve—whether lubricated or even when dry—is greatly reduced. One valve treated in this way is operating continuously throughout the exhibition. Other valves, so arranged as to have equal thrust on the taper, demonstrate the effect on turning effort of the process. Increased corrosion resistance is a further advantage that is claimed for the process.

Valves displayed on the stand include sizes from  $\frac{1}{2}$  to 18 in. for pressures from extreme vacuum to 5,000 p.s.i., and there are also a number of gauge glass fittings.

For further details  
of the plant and  
products described,  
please use the  
coupon on page 346

### NEW PRODUCTS IN BRIEF

Automatic scanning of process variables on a remote plant. Small control station measuring approx. 10 in. square comprises little more than a telephone-type dial and a reading instrument with a 4-in.-long scale and alarm lamps. Any one of 100 or more points (makers state actual number is virtually unlimited) can be connected to the measuring indicator by operation of the dial. This is accomplished over a single pair of wires between plant and control room. The establishment of a number of control stations around an extensive plant, such as a refinery, is possible by installation of a ring main system. Telephone communication is also available over the same lines. (Electroflo Meters Co. Ltd.) \*

Heat-resisting aluminium paint, stated to withstand temperatures up to 1,000°F. when dry. Covering power: 80 to 90 sq.yd./gal. normal for brushing and approx. 45 sq. yd. for spraying. Material is a petroleum mixture under definition of the Petroleum (Mixture) Order, 1929, and has a flash point below 73°F. Price, £17 5s./gal. (in 1-gal. cans). (Allweather Paints Ltd.) \*

Accurate analyses of steel samples are made in laboratory and results conveyed back electronically to the melting shop in less than 10 min. in a British steelworks. A new direct-reading instrument, designed for rapid routine spectrographic analysis is used. (United Steel Companies Ltd.) \*

New range of phosphating processes are stated to cover entire phosphating field. Special attention has been paid to manganese processes, claimed to have a number of advantages over zinc processes. Typical applications for phosphating processes include the treatment of hot- and cold-rolled sheet, forgings and extruded steel, precision and machined parts, and steelwork to be cold drawn or stamped. (Jenolizing Co. Ltd.) \*

Electro-magnetic transducer system for the remote indication of pressures and mechanical displacements has application on turbines, in oil supply systems, atomic factories and elsewhere. Enables mechanical displacements of less than 0.001 in. to be measured directly, makers state, and, when used with suitable pressure-responsive element such as a diaphragm, can be adapted for measuring

pressures from a few inches of water gauge to over 200 p.s.i. When used with a Bourdon tube will measure pressures up to 10,000 p.s.i. (Salford Electrical Instruments Ltd.) \*

Photochemical reactor, designed for laboratory use, or even as a small-scale production unit, for the preparation of compounds by means of ultra-violet or visible radiation. The apparatus can be used with various medium-pressure and low-pressure mercury vapour tubes to provide different ultra-violet sources and wavelengths. (Engelhard Industries Ltd.) \*

Chemical-resistant coating is stated to have protected inside walls of an industrial chimney against sulphuric waste gases over a two-years' operating period. Two layers of emulsion—chemical-resistant synthetic resin finely dispersed in water are given a mastix cover consisting of emulsion and filler (e.g. quartz meal), then walls are again sprayed or brushed with emulsion. (Farbwerke Hoechst A.G., Germany.) \*

Hydro-rotor industrial wet washer for removing finely divided dust particles from air streams (as, for example, from grinding, polishing and buffing machines, paint-spraying booths, etc.) comprises a water tank, rotating helix and squirrel cage, set of eliminator plates and either an axial or centrifugal fan. May be supplied in various arrangements to suit the particular application as, for example, with scraper bottom and/or continuous sludge filter. Other applications in compact form include its use as an industrial air-conditioning washer or humidifier. (Keith Blackman Ltd.) \*

Brominated butyl rubber, *Hycar* 2202. The modification of the poly-isobutylene copolymer by bromine confers certain desirable properties which are absent from conventional butyl rubbers, makers claim. Of these properties the three most important are increased rate of vulcanisation, improved compatibility with natural and GR-S rubbers and improved adhesion to rubbers and metals. (British Geon Ltd.) \*

New type of fibre drum with interior lined with heavy aluminium foil. Developed specially for dry goods, or goods which have to retain their moisture content. Available in three dimensions—12, 14½ and 16 in. to any depth up to 36 in.—and stated to have an extremely high weight-carrying capacity. (Venesta Ltd.)

## New Books

### Chemical Process Design

The reviewer has been particularly interested in seeing the second edition\* of a book which he used as a text in a course on chemical engineering thermodynamics. The original authors have been wise in enlisting another of their teaching colleagues, Prof. Ragatz, who previously assisted them in revision of two chapters.

The first impression of the new edition confirms its thorough treatment of the subject, and a great deal of newer and up-to-date material has been incorporated. This has resulted in an increase of the size of the book by nearly 70 pages and a proportionately much higher increase in price (70%) over the first edition. There are several additional diagrams and some of them have been redrawn for clarity of presentation. An entirely new chapter on mathematical procedures and conversion of units has been added. Also, the material relating to adsorption previously scattered in two chapters (Solubility and Crystallization; Thermochemistry) now forms a part of the new chapter on this subject. Apart from these two major changes, the general arrangement of the contents is similar to that of the previous edition. Some of the other notable additions are: extraction calculations; equilibria in ternary systems and time lag to attain steady state conditions in stirred vessels.

Several new problems have been added at the end of each chapter and in many cases the numerical values of temperature, pressure or composition, etc., have been altered. A particularly welcome addition is that answers have now been provided for at least some of the problems.

As before, the subject-matter of the book is well illustrated by numerous worked examples. In the very elaborate one relating to the chamber acid plant, the Hausbrand type of diagrams have now been omitted. These diagrams are an excellent method for presenting energy balances and their omission, presumably to save space, is to be regretted. For the estimation of critical constants, the more recent group contribution method due to Riedel replaces the Meissner's method based on parachor and molar refraction. The tabulation of critical con-

\**Chemical Process Principles, Part 1—Material and Energy Balances*, by O. A. Hougen, K. M. Watson and R. A. Ragatz. 2nd Edition. Chapman & Hall, 1954, pp. 538, 68s.

stants has been made much more extensive.

In the chapter on thermochemistry, the tables of heats of formation and solution have been revised and brought up to date. Other useful features of this chapter are: enthalpy-concentration as well as partial and total specific volume curves for the system, ethanol-water; and simple diagrams illustrating the effect of temperature and pressure on heat of reaction. The potentially important nuclear reactions have not escaped the attention of the authors. In a solved example it is shown that 119.5 g./day of  $U_{235}$  are required to operate a commercial power unit generating 100 mw. of heat, the corresponding amount of coal being  $26.4 \times 10^7$  g.

In brief, the book adequately fulfills its objective of helping the reader '... to reason accurately and concisely in the application of the principles of physics and chemistry to the solution of industrial problems.' It will continue to prove extremely useful both to students and workers in the chemical industry.

O. P. KHARBANDA

### Engineering Materials

The appearance of Part 4 of the Dechema tables of engineering materials\* has followed agreeably soon after the previous issues (reviewed April, 1955), giving a pointer to the quick completion of the work which is to contain 1,000 sheets. This issue has 100 sheets, making the total to date 401. It covers the reagents Butane to Cavite and includes calcium and 31 of its compounds, several of the more important ones running to a second sheet of notes, i.e. calcium bisulphite, chloride and phosphate.

It is now possible to obtain stiff binding covers taking two parts each and also a complete index list of all the sheets issued so far for checking purposes.

FELIX SINGER

\**Dechema-Werkstoff-Tabelle, Part 4*, by E. Rabald and H. Bretschneider. 3rd Edition. Chemie GmbH., Weinheim, 1955.

**Forming aluminium sheet.** In 10 chapters, copiously illustrated, a 64-page book, published by the Northern Aluminium Co. Ltd., presents the fundamental concepts of the usage of aluminium sheet. The subjects dealt with include the characteristics of the metal, and its manipulation in bending, spinning, deep drawing, pressing, drop-hammer forming, rubber-die pressing, stretch-forming,

hand-forming, blanking, piercing and various supplementary operations. All are illustrated by examples from actual practice, which are described in detail.

**'British Chemical Plant, 1955.'** This directory, issued by the British Chemical Plant Manufacturers Association, is a biennial publication, the last edition having been issued in May 1953. This issue is arranged in a similar manner to the previous one, having three main sections: (1) a list of members with their addresses and, where they have wished to publish them, the names and addresses of their overseas agents; (2) an illustrated section consisting of members' advertisements; and (3) a classified index of products and services prefaced by advice to enquirers and followed by a key in French, German and Spanish.

The continued growth of the Association and the increased scope of the publication is illustrated by a comparison between the 1953 and current edition. The number of members now listed is 211, against 192 in 1953; and the number of pages is 393 (274 illustrated) against 356 (246 illustrated) in 1953. There are 121 entries in the illustrated section compared with 109 in 1953; the number of headings and sub-headings in the classified index has also increased from 1,204 in 1953 to 1,325 in 1955.

A limited number of copies is being held to meet requests from chemical plant users who will be supplied free of charge on application to the Secretary of the Association at 14 Suffolk Street, S.W.1.

**Carbon tower packing.** The grid-type packing, well known for water-cooling towers, has a far superior performance to that of random packings, but was not developed for the chemical industry, due to the general unsuitability of wood as a material of construction. The introduction and development of the carbon *Paragrid* packing has overcome this difficulty and is able to offer to the chemical industry a packing suitable for handling most complex acid, alkali and solvent liquors, combined with the superior operating characteristics of the grid-type packing. The foregoing statements are included in the introduction to a pamphlet (8 pages, illustrated) issued by Powell Duffryn Carbon Products Ltd. A brief section on *Delanium* carbon is followed by an explanation how *Paragrid* packing is constructed; performance data are also given along with some remarks on tower sizes and applications of the packing. Finally, some design data are included.

## ★ Personal Paragraphs ★

★ **Sir Charles Drummond Ellis, F.R.S.**, has been appointed scientific adviser to the Gas Council. This is a part-time appointment. He has also been appointed a member of the Gas Council's Research Advisory Committee. Among other important appointments, Sir Charles has been a member of the Advisory Council on Scientific Research and Technical Development to the Ministry of Supply. From 1946 until early 1955 he was scientific member of the National Coal Board and a member of the Advisory Council to the Minister of Fuel and Power.



Mr. F. A. C. Guepin.

★ **Mr. F. A. C. Guepin**, chairman of the Shell Chemical Co. Ltd., the formation of which is reported on another page, is a managing director of the Shell Petroleum Co. and of the Bataafsche Petroleum Maatschappij, and a director of many other companies connected with the Royal Dutch/Shell Group. **Mr. W. F. Mitchell**, vice-chairman of the new company, is a Canadian who was previously general sales manager of Shell Co. of Canada. He is now head of Chemical Industry Administration, which is the department of the Shell Petroleum Co., London, responsible for the development of Shell's worldwide chemical interests outside the United States and Canada. **Mr. L. H.**



Mr. W. F. Mitchell.

**Williams**, managing director of Shell Chemical Co. Ltd., was previously general manager of Shell Chemicals Distributing Co. of Africa Ltd. He returned to London in 1950 as deputy commercial manager of Shell's chemical industry administration.

★ **Mr. J. D. Nuttall** has been co-opted as a director of the Triplex Safety Glass Co. Ltd. He joined the company in 1946 from the Ministry of

Aircraft Production and was appointed company secretary in January 1948. Since 1952 he has been a director of Quickfit & Quartz Ltd., a subsidiary of the Triplex group.

★ **Mr. W. R. Storey, M.B.E.**, who was managing director of the I.C.I. Salt Division until he retired recently, has joined the Graviner Manufacturing Co. Ltd. as technical adviser, with particular reference to industrial explosion suppression and protection.

★ **Mr. W. C. Foster**, former U.S. Deputy Secretary of Defense and former president of the Manufacturing Chemists' Association Inc., has become an executive vice-president of Olin Mathieson Chemical Corp., U.S.A.

★ Babcock & Wilcox Ltd. announce the retirement of **Mr. J. Smith** as managing director of Edwin Danks & Co. (Oldbury) Ltd. He has been appointed deputy chairman of the company. **Mr. L. W. H. Rea**, whose appointment as general manager of Edwin Danks has been previously announced, has been appointed to the managing directorship.

★ **Mr. Douglas Wilson** (United Steel Companies Ltd.) retired from the chairmanship of the Council of British Manufacturers of Petroleum Equipment at the close of his three-year term of office recently. His successor is **Mr. G. V. Sims**, managing director of Le Grand Sutcliff & Gell Ltd.



Mr. Harry F. Dever, president of the Scientific Apparatus Makers of America, made a special trip across the Atlantic recently to visit the British Instrument Industries Exhibition. In the photograph Mr. Dever (right) chats to Mr. G. P. Clay of Imperial Chemical Industries Ltd. and Mr. V. D. MacLachlan, sales director of Honeywell-Brown Ltd. Mr. Dever is president of the Brown Instruments Division, Minneapolis-Honeywell Regulator Co.—the American associates of Honeywell-Brown Ltd.

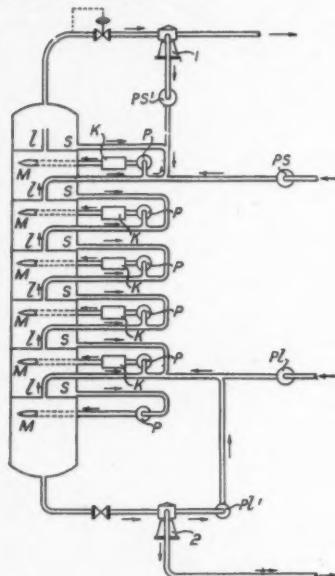
# Chemical Engineering Invention

## RECENT BRITISH PATENT CLAIMS

### Extracting liquids

In a process for the continuous extraction of two liquid phases of different density in a multi-stage mixing column, the extracted phases leaving the top and base of the column are each passed to a centrifuge wherein the contaminating phase withdrawn from the column is separated and thereafter returned to the column.

As shown, the heavy phase *S* is pumped into the top of an extraction column by a pump *PS* and the light phase *L* into the bottom of the column by a pump *PL*. The extracted light phase which is still contaminated with heavy phase is conducted from the top of the column to a centrifuge 1 from which the light phase is removed as an end product while the separated heavy phase is returned to the top of the column by means of a pump *PS*<sup>1</sup>. The heavier phase at the bottom of the column is similarly treated by centrifuge 2, the contaminating light phase being returned to the column by means of a pump *PL*<sup>1</sup>.



In each stage of the tower, light liquid is drawn axially from the stage below and heavier liquid from the periphery of the stage above by a rotary pump *P*, the mixed liquids being fed into the corresponding chamber via a tangentially disposed inlet *M*. Heaters or coolers *K* may be included in the circuits to control the temperatures in the various stages.

The apparatus may be used in the refining of a mineral oil with fuming sulphuric acid to produce white oil, if desired under pressure.—699,133, Anglo-Iranian Oil Co. Ltd.

### Ball mill

A grinding mill comprising a rotary cylinder with inwardly projecting crusher bars on its cylindrical wall is provided with a ball charge in the form of at least 10 balls. These weigh at least 4 lb. each, have a diameter of more than about 3 in. and occupy in all at least 0.35% and not more than 3% of the mill volume excluding voids between the balls.

The total charge of material to be ground and balls consists of from 20 to 32% of the mill volume, inclusive of voids, and the drum is rotated about a horizontal axis at a speed of between 84 and 90% of its critical speed. The balls may be made from tungsten carbide or alloy steel. Specifications 632,532 and 696,137 are referred to.—696,164, D. Weston.

### Spray evaporator

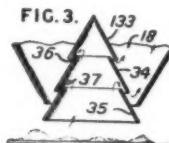
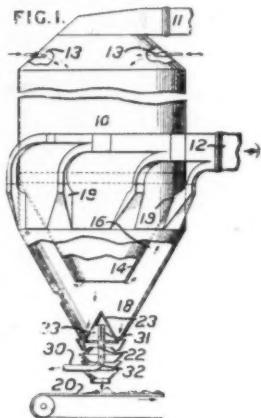
A spray evaporator for obtaining stable, freely flowing powders from solutions and slurries is described. The solution or slurry is sprayed into the top of the evaporator and contacted therein with hot air. In the base of the evaporator, baffles are provided over which the particles move downwards, and there are means for inducing cool air to pass transversely through the downwardly moving particles. The drying of soaps, and of wetting agents such as aliphatic sulphates and sulphonates and alkyl aryl sulphonates, is referred to, also the drying of amino acids, proteins (e.g. eggs) and salts (carbonates and borates).

In the evaporator shown in Fig. 1, the solution is sprayed into shell 10 through circularly arranged nozzles 13, and hot air is introduced through conduit 11. Partially dried particles and air are discharged into chamber 18 through a hole in the base of frusto-conical section 14. The air changes direction and passes through annular space 16 and ducts 19 to outlet conduit 12, but the particles travel on downwardly to deflecting wall 23. The particles then pass through opening 22 and flow over a series of annular baffles to conveyor 20.

While falling between the baffles,

the particles are dried and cooled by air at atmospheric or room temperature flowing transversely through them; the cooling streams being induced by the application of suction at the lower end of pipe 30. Cooling air enters the pipe 30 through openings 32 and through the open upper end 31, turbulence in cone 23 being prevented by four vanes 33 extending from the pipe to the inner wall of the cone.

Fig. 3 shows another embodiment of the final drying and cooling system. In this case the particles flow over



series of spaced conical baffles 133, 34, 35, positioned within the outlet of chamber 18, and the cooling air is sucked, through spaces 36, 37 and 38 transversely through the falling particles, into chamber 18 by means of a suction device attached to conduit 12 (Fig. 1).—694,343, Purex Corporation Ltd.

**Insulating materials.** A booklet from Midland Silicones Ltd. describes a range of electrical insulating materials consisting of silicone resins and elastomers in various combinations with glass fibre, mica and asbestos. The materials vary from thin flexible sheets and sleeving to rigid structural components which may be over 1-in. thick. Also included are insulated winding wires and power cables.

# World News

## GREAT BRITAIN

### Polythene plant for Scotland

The petrochemicals plant at Grangemouth, Scotland, the expansion plans for which we featured in August, is to have a new neighbour—a polythene (polyethylene) plant that is to be built by Union Carbide Ltd. This associate company of the Union Carbide & Carbon Co. (U.S.A.) will be the first British company other than Imperial Chemical Industries Ltd. to enter this field.

Drawing the necessary supplies of ethylene from the adjacent plant of British Chemicals Ltd., Union Carbide will produce polythene of the same quality and types as the American company produces. Bakelite Ltd. are to market the product. The polythene plant is expected to be in production by the third quarter of 1957. In the meantime, Bakelite will have available quantities of imported polythene for sales development purposes.

### Shell Chemical Co. Ltd.

It has been decided to concentrate all Shell's chemical manufacturing and marketing activities in the U.K. and Eire in one company to be called Shell Chemical Co. Ltd. A statement from Shell explains that this step is being taken in view of the increasingly rapid growth of Shell's chemical activities and to facilitate the execution of plans for further expansion.

The new company, which has an authorised capital of £10 million, will take over the activities of Shell Chemical Manufacturing Co. Ltd. and Shell Chemicals Ltd. These activities include the manufacture and marketing of detergents, solvents, resins and agricultural products and a wide range of chemical intermediates. Petrochemicals Ltd., which was recently acquired by Shell Chemicals Ltd., will become a wholly owned subsidiary of Shell Chemical Co. Ltd. and will continue its chemical manufacturing and marketing activities as a separate entity.

The board of Shell Chemical Co. Ltd. will be constituted as follows: chairman, Mr. F. A. C. Guepin; vice-chairman, Mr. W. F. Mitchell; managing director, Mr. L. H. Williams; commercial director and deputy to the managing director, Mr. G. H. W. Cullinan (previously general manager of Shell Chemicals Ltd.); executive director, manufacturing, Mr. E. le Q. Herbert (managing director of Shell

Refining & Marketing Co. Ltd.). The other directors of the company will be Mr. J. W. Platt, Sir Robert Robinson, O.M., F.R.S., Mr. A. D. Koeleman, Dr. M. A. Matthews and Mr. F. F. Mackley.

### 'Segas' plant for gas works

The North Thames Gas Board has recently placed an order with the Power-Gas Corporation Ltd. for a Segas catalytic oil gas installation at their Uxbridge works. The plant will consist of two units each producing 1½ million cu.ft./day of gas and will be complete with all necessary ancillary equipment. A single waste-heat boiler will serve both units, and a separate oil-fired boiler will be provided to supply the balance of steam requirements. A low-pressure steam system incorporating a steam accumulator will take the exhaust steam from the exhauster and air blower to provide process steam to the plant.

The project includes foundations, building, oil storage tanks, relief gas holder, electrostatic detarrier and naphthalene washer. Provision is made for the recirculation of cooling liquor over a cooling tower from the direct-contact washer cooler. It is expected that the plant will be in operation by the end of 1956.

### C.R.L. 'open days'

The Chemical Research Laboratory, Teddington, is holding a series of 'open days' from September 27 to 29, when an exhibition of the work in progress may be seen.

### Platormate splitter

An order has been received by W. J. Fraser & Co. Ltd. for a platormate splitter unit to be constructed at Llandarcy refinery for the British Petroleum Co. Ltd. This is in effect a repeat order, following a contract recently awarded to Frasers for a similar unit at the Isle of Grain refinery.

### Fuel oil distribution

The Hargreaves Group of companies have concluded an agreement with the Esso Petroleum Co. Ltd. whereby they are appointed as distributors of Esso fuel oils over a wide area in the north of England and north Midlands.

Fuel-oil supplies will be drawn from the Esso refinery at Fawley and the Hargreaves Group will operate its own road tanker fleet for the supply of fuel oils to users.

### Automatic control conference

A joint conference on automatic control in the process industries will be held by the Institution of Chemical Engineers and the Society of Instrument Technology in London on October 4. The conference will cover a number of aspects of automatic control in relation to the design and operation of process plant. The programme will develop a direct and fundamental approach for the benefit of those without specialised knowledge of the field and will clarify terminology, definitions and scope. Particular emphasis will be laid on the presentation of data in relation to practical installations and applications without undue comment on instrument design or construction.

A provisional programme that has been issued gives synopses of papers that are to be read, under six separate headings.

### Sulphuric acid from Whitehaven

At a recent Press conference in London, Mr. F. Schon, chairman of Marchon Products Ltd. and its subsidiary, Solway Chemicals Ltd., revealed some new facts about the sulphuric acid plant and the anhydrite mine at Whitehaven, Cumberland, which are now in production. He pointed out that certain aspects of the project have changed since it was first embarked upon in 1951. First, the project was estimated to cost £2 million, and the actual cost will be nearer £3 million on completion. This is due to the general increase in prices and also to certain modifications in the design; for instance, the productive capacity of the anhydrite mine—originally scheduled to be 175,000 tons p.a.—will soon be producing at a rate of 350,000 tons p.a.

The sulphuric acid and cement plant, which consists of two independent and interchangeable units—one now completed, the other available for starting up shortly—have now an annual capacity of 100,000 tons of sulphuric acid and 100,000 tons of cement.

As in 1952, the Marchon parent company are still in a position to absorb half of the total output of sulphuric acid. The other half will be available for sale to industry. With regard to the cement output, a long-term agreement has been entered into with the Associated Portland Cement Manufacturers Ltd., and the disposal of the whole of the cement has thus been taken care of.

As to the disposal of the 50,000 tons of sulphuric acid over and above the Marchon requirements, Mr. Schon

pointed out that the company face a situation somewhat altered from that generally expected four years ago. At that time, the availability of sulphuric acid was affected by export restrictions placed by the United States on elemental sulphur, which was and still is Britain's chief raw material for sulphuric acid production. A national sulphuric acid plan, of which the Solway plant is a unit, was framed for dealing with the anticipated shortage of sulphur. But in 1954 sulphur again became freely available from the U.S., and relaxation of the import and currency restrictions in the U.K. amounted practically to the freeing of imports of American sulphur. Hence the changed position today.

However, Marchon Products Ltd., who will be responsible for the disposal of acid, have for years been engaged in the highly competitive detergent trade, and are not disturbed at the prospect of selling 50,000 tons of acid under what may become also highly competitive conditions, Mr. Schon said. He expressed a belief that the acid, produced from indigenous raw material, 'will be able to compete in cost with acid produced by any other means, from any other raw materials, wherever they may come from, provided of course that we can run out plant on an economical capacity basis.'

#### F.M.A. and S.M.A. publicity

The Fertiliser Manufacturers' Association announce that the publicity and public relations activities which they initiated three years ago, in conjunction with the Superphosphate Manufacturers' Association, have had a most encouraging reception and are now to be extended. In future, the Fertiliser Manufacturers' Association will be responsible for this work and will be supported by bodies representing producers of basic slag, nitrogen, potash and superphosphate.

#### Chemical cleaning factory

A factory that has been opened at Willington Quay, Northumberland, by Houseman & Thompson Ltd. is designed to extend the company's activities in the field of chemical cleaning for industrial and marine equipment. The factory is equipped to handle a wide range of industrial machinery including all types of heat exchangers from modern high-pressure boilers to domestic radiators.

#### Change of address

After an interval of 15 years the registered office of the Mond Nickel Co. Ltd. is once again Thames House, Millbank, London, S.W.1.

#### A.P.V. and chemical engineering

The development of a modified process for the treatment of milk at much higher temperatures was referred to as a major advance of the A.P.V. Co. Ltd. during 1954 by Dr. R. J. S. Seligman, the chairman, in his annual statement. The company believe that this process may be very widely adopted in the near future.

The company's chemical engineering department in 1954 had the largest order book recorded so far in any one year. Early in the year much work was in progress in the A.P.V. factories connected with the development of atomic energy. This has now ceased, but research work is in hand which may prove of importance for the development of atomic energy for civilian uses.

#### Jobs for older workers

The Ministry of Labour's Appointments Service continues its good work of finding jobs in industry for older people. As a recent example two mechanical engineers, aged 69 and 65, were placed as assistants to the chief engineer in a firm of paper manufacturers, to help establish a plant register. Both these men had previously been unemployed for a considerable time.

#### 'Bisol' solvents price changes

Reductions in the prices of *n*-butyl alcohol and butyl acetate are announced by British Industrial Solvents. At the same time, new types of price schedules for these materials, for ethyl, isopropyl and amyl acetates, and for methyl ethyl ketone, depending on the size and type of each delivery, have been introduced.

#### New 2,000-ton forging press

A new 2,000-ton, four-column press has recently been installed at the Renfrew works of Babcock & Wilcox Ltd. to assist in the production of boiler drums. Up to now the ends of the steam drums have been pressed in the forge department and machined in the main machine shop. The largest press hitherto available for this particular work has been one of 480 tons, which has involved multi-stage pressing operations for the thicker plates. The new press will enable drum ends of any size so far envisaged to be easily handled and should be of considerable assistance to the future programme in atomic power plant.

The press will take the heaviest plate rolled with a maximum width of 12 ft. 6 in., and it is suitable for pressing drum ends from 12 ft. 6 in. circular blanks 7-in. thick.

#### Welding development service

American funds for advisory work on welding have been made available to the British Welding Research Association through the Department of Scientific and Industrial Research. These funds will enable the B.W.R.A. to increase its development service to British industry. The service will be based on the Association's considerable experience of research and development and, within the limits of the staff available, assistance will be given on any welding problems which may arise during the next two years.

The object of granting the funds is to increase British productivity and the Association will therefore be concerned with:

- (1) giving technical advice where users of welding processes are encountering difficulties;
- (2) encouraging the use of welding wherever this will lead to better productivity;
- (3) improving the quality of welding;
- (4) advising on design for welding.

#### A successful year for Johnson, Matthey

Johnson, Matthey & Co. Ltd. are to transfer to a new site, outside of London, the whole of the chemical work which from the beginnings of the company up to the present time has been carried out in the works at Hatton Garden. Referring to this very formidable task in his annual review, the chairman of the company, Mr. Hay W. P. Matthey, stated that in recent years this work, particularly in the refining of the platinum group metals, has so greatly increased in volume that the company were now working in such cramped conditions as to impair the efficiency of their operations. Further, the fume omitted from the works threatens to prove objectionable to neighbours and to the local authorities.

A suitable site has been found at Royston, Herts., and plans are being prepared for the new works.

Universal-Matthey Products Ltd., the company founded by Johnson, Matthey in equal partnership with the Universal Oil Products Co., completed the erection of its plant and started to produce platinum-bearing catalyst for the oil-refining industry in November 1954, and has continued working day and night without interruption since that time.

For the year ended March 31, 1955, Johnson, Matthey & Co. Ltd. earned a net profit, after providing for taxation, of £769,372, compared with £445,530 in the previous year.

## AUSTRALIA

### New plant at Kwinana

To meet the increasing demand in Australia for 'bottled gas,' a liquid petroleum gas bottling plant is to be installed at British Petroleum Co.'s Kwinana refinery, Western Australia. Butane and propane gases will be taken from the distillation units and, after treatment, will be filled into containers at the bottling plant. The plant will be capable of filling containers of 32 lb., 100 lb. and 1 ton, and will also include a filling point for bulk vehicle loading. Work on the unit is expected to start towards the end of the year.

Also at Kwinana a bitumen plant has started production. Installed at the request of the West Australian Government, it will produce about 2,000 tons p.a. of bitumen for road construction.

## TURKEY

### New chemical plant

A new chemical plant is being built at Kutefia in Turkey by the Badische Annolin und Soda Fabrik concern. The plant will be ready in 1958 and will produce 60,000 tons p.a. of ammonium sulphate, 50,000 tons of sulphuric and nitric acids and 10,000 tons of technical ammonium nitrate used for the manufacture of explosives.

### Ferro-chrome and caustic projects

The Etibank has signed a contract with two French firms to form a company with a capital of T.L. 5 million for the manufacture of ferro-chrome. Capacity will be 25,000 tons p.a. of chrome ore and about 8,000 tons p.a. of ferro-chrome. About 4,000 tons p.a. of calcium carbide will be produced as well. It is proposed to build at Ayvalik a caustic-soda factory with a capacity of 5,000 tons p.a.

## SPAIN

### Chemical firm to expand

The Union Espanola de Explosives is to expand its output appreciably by new installations at its works in Seville. It is planned to raise superphosphate production by 120,000 tons p.a. and also to produce 31,500 tons of sulphuric acid. Total value of machinery for the new installations is placed at \$85.5 million, of which part will be manufactured in Spain and part imported.

## BURMA

### Copper deposits

As the result of a prospection carried out by a Czechoslovak mining engineer and a geologist it is believed that there are large reserves of copper pyrites suitable for economic exploitation in



### CAT CRACKER MODIFICATIONS

Rapid technical advances are taking place in the petroleum industry in the 'hot war' to raise the octane value of fuel. Recently modifications have taken place 275 ft. above ground level inside the main column of the T.C.C. ('Thermofor' catalytic cracking) unit at the Coryton refinery of the Vacuum Oil Co. Ltd. to improve the performance of this unit.

The steel frame and dead-hard castings were supplied by Birwelco Ltd., of Birmingham, and installed during the programmed shut-down of the plant.

The photograph shows a welder at work inside the cracking tower on this unit.

the hills of the Monywa district. In the ores so far analysed there is an iron and sulphur content. A relatively high copper content is expected to be established when samples have been subjected to proper chemical analysis in Czechoslovakia.

## ISRAEL

### Fertiliser industry

Field experiments with peat obtained from the drained areas of the Huleh swamps may lead to the establishment of a local organic nitrogenous fertiliser industry using this peat as its basic raw material. Investigations have shown that the Huleh peat contains from 50 to 80% of organic matter with 1½ to 2½% of nitrogen. The draining of the Huleh swamps has uncovered an area of 11,000 dunams of peat, which varies in depth from 4 to 8 m. Calculated at only 4-m. deep, the reserves of peat in this area amount to over 7 million tons. The peat is to be processed with ammonia, for the manufacture of which a plant is now in the final stages of construction. This will produce a quick-acting fertiliser containing a high percentage of nitrogen. The use of local peat will thus enable the production of nitro-

genous fertiliser exclusively from local materials and will therefore result in a saving of foreign currency.

A new Government-owned phosphoric acid plant will shortly produce superphosphate fertiliser from the Negev phosphates. At present the superphosphates have a 22% strength, but when additional equipment now on order arrives, the plant will produce an extremely valuable triple-superphosphate of 42 to 46% concentration.

## JAMAICA

### Cement

Caribbean Cement Co. Ltd., the sole producers of cement in Jamaica, are increasing their productive capacity from 100,000 to 120,000 tons p.a. at a cost of £145,000.

### Soda-ash project

A new company, Caribbean Chemical Co. Ltd., plan to start work within the next two or three months on the construction of a factory at a cost of about £2 million for the production of soda ash. They hope to complete it within 18 months and to produce at the rate of 125 tons day, not only for local consumption but also for export.

## GERMANY

### I.G. Farben reconcentration

The Farbwerke Hoechst disclosed at its annual meeting in Frankfurt that it did not expect the reconcentration with the other two leading successors to the former I.G. Farben chemical combine to come about for the next few years.

A spokesman for the company added, however, that it was considered necessary that the three companies should continue to work 'on a basis of friendly co-operation, especially to avoid useless double investments.'

## WEST AFRICA

### Acetylene and cellulose factories

A new factory—'Angazes'—was opened in Luanda recently for the manufacture of acetylene and the Companhia de Celulose do Ultramar Portugues has been authorised to install a cellulose factory. The location of this latter factory is not yet known.

## ITALY

### Potassium deposit discovered

A large potassium deposit which has been located at Villa Priolo, on the island of Sicily, may prove to be the largest in Europe. The deposit is situated at the relatively shallow depth of 80 ft., is 1,600-ft. long and 73-ft. deep. It is expected to yield 40% pure potassium.

## EGYPT

### **Oil refinery project**

A new refinery at Mostorad, near Cairo, is to be linked to Suez by a 130-km. pipeline, about half of which has already been laid. The refinery, which it is claimed will be finished by the end of the year, will have an annual production of 2 million tons. Work on the new Shell-Mex refinery at Alexandria also continues, and production, expected to commence in October 1956, will be 600 tons/day.

## INDIA

### **Fertiliser and chemical projects**

Highlights of industrial development in the public sector envisaged under India's second five-year plan include the setting up of two or three more fertiliser factories, a second DDT factory, a plant for the manufacture of heavy electrical equipment and a synthetic oil plant.

One of the new fertiliser factories planned is to be located at Bhakra Nangal, where ammonium nitrate will be manufactured. The second DDT factory is to be set up at Alwaye in Travancore-Cochin.

The increase in fertiliser production aimed at by the second five-year plan period is 170,000 tons in terms of nitrogen content. Present fertiliser manufacturing capacity in the country is estimated at roughly 100,000 tons p.a. The new plant in Sindri for the manufacture of urea and ammonium sulphate-nitrate from coke-oven gas, expected to go into production at the beginning of 1958, will add another 40,000 tons p.a. to current output.

Further development of fertiliser production amounting to 80,000 tons in terms of nitrogen, at an estimated cost of about 250 million rupees, is likely to be taken up at a later stage.

## BRAZIL

### **Petroleum and fertiliser plants**

The petroleum refinery at Cubatao, which was opened recently, has been officially named the Arthur Bernardes Refinery. It is at present operating on imported crude oil and the refinery aims at production of 60,000 bbl./day of refined oil which it hopes to increase to 75,000 bbl.

A project at Cubatao (also under Petrobras) is the construction of a fertiliser factory which it is hoped will be in production during the first half of 1956. The estimated production capacity of the plant is 375 tons of fertiliser and 35,000 cu. m. of hydrogen. Together with this will be an asphalt factory capable of producing 116,000 tons p.a. which, according to

present statistics, should be sufficient for Brazil's needs without further importation. This factory is expected to be in production by the end of this year.

## CHILE

### **Fertilisers and chemicals**

A new flotation plant for the treatment of apatite (a phosphate of lime) has begun production in the Coquimbo district. The plant is owned by the Sociedad Anonima de Minas y Fertilizantes.

### **New projects**

The German Krupp organisation is studying the possibility of establishing plants in Chile for the manufacture of explosives and chemical products.

## SWEDEN

### **Fertiliser consumption**

Sweden's annual consumption of potassium fertiliser, in terms of K<sub>2</sub>O, has increased from 20,000 tons in 1911-15 to 74,000 tons in 1954, according to a report presented to the Swedish Agricultural Academy at Stockholm. Maximum requirements are estimated at 185,000 tons. During the same period, Sweden's consumption of nitrogenous fertilisers, in terms of N content, increased from 5,000 to 80,000 tons p.a. Maximum requirements of these fertilisers are estimated at 150,000 tons.

Following the completion of the new ammonia factory at Kvarntorp in central Sweden next year and the expansion of certain other factories, Sweden will be able to produce 55,000 tons p.a. of nitrogen. This corresponds to 70% of current consumption.

In the field of phosphatic fertilisers, Sweden's annual consumption is now about 110,000 tons in terms of phosphate content, the maximum requirement being estimated at 205,000 tons. The total capacity of Swedish factories now amounts to about 130,000 tons of phosphates, of which 13,000 tons consist of basic slag and 117,000 tons of superphosphates. Sweden's iron-ore deposits contain extractable phosphate rock equivalent to 200 million tons of 20% superphosphate, or sufficient to cover domestic consumption for about 400 years.

The consumption of lime, of which Sweden has rich deposits, has been decreasing in recent years.

## RHODESIA

### **Cement**

The Rhodesia Cement Co. have stated that the total production capacity for cement in the Federation is

now 575,000 tons p.a. They say that supply has now overtaken demand and that they are convinced that local production should now meet the requirements for the Kariba project in addition to all other Federation demands. The company propose to build an additional cement works in the Blantyre area which will process clinker supplied from its works at Colleen Bawn, Southern Rhodesia, to meet demand in Nyasaland.

## FRENCH MOROCCO

### **Industrial progress**

A fourth oven now operates in the Casablanca cement works which, with Agadir and Meknes produces 600,000 tons p.a. of cement—about 90% of the demand. Production of electricity stands at 850 million kwh. and the target is 1,000 kwh. this year. 767,000 tons of petroleum products are consumed in Morocco each year. Local petroleum production stands at 117,000 tons after 20 years of prospecting and development.

## HUNGARY

### **Chemical plant and allied exports**

According to the newspaper *Magyar Nemzet*, Hungarian industry has received such a flood of orders and enquiries for plans from abroad in the past year that special export offices have been set up in four ministries to deal with them. More than 600 requests for plans of chemical works and power plants have been received, states the report.

Among the recent commissions that are cited are two drug factories that Hungarian engineers are building in Bulgaria. In Argentina, oxygen factories are being built on Hungarian documentation, with Hungarian equipment. China has been sent plans for an oxygen plant, together with the mechanical equipment. China and Indonesia have asked for plans of a fertiliser factory.

Plans for cement factories have been requested by Iraq, Syria and Poland. In Uruguay, Hungarian engineers planned the dust extraction and ventilation equipment of a big cement works.

The Food Industry Planning Institute has built several ice factories and plant oil mills in Turkey, and provided the plans for three canning plants built in Albania, a plant-oil-extraction factory in Indonesia and a condensed milk factory in Bulgaria. Tenders for sugar factories have been sent recently to China, Chile and Rumania, and for a cold storage plant to Turkey.

## BELGIUM

### Petro-chemicals project

A new petro-chemicals facility, to be built near Antwerp, Belgium, will include major ethylene oxide and ethylene glycol production units. The Scientific Design Co. Inc., United States, has been awarded contracts for the design and engineering of these components. The plant as a whole will be operated by the Societe Chimique des Derives du Petrole, known also as 'Petrochim.' It is scheduled for completion in 1956.

The process of ethylene oxide manufacture to be employed does not require the use of chlorine. Ethylene is united directly to oxygen over a catalyst.

The entire 'Petrochim' project is financed by 11 major Belgian corporations, who have \$8 million available for the project, including a loan of \$2 million extended by the Belgian Government. Leading shareholders include the Société Belge d'Azote, Carbochimique, Petrofina and Sofina.

## NORWAY

### Atomic power for paper production?

The Norwegian Institute for Atomic Energy has submitted proposals to the Government for building an atomic reactor with a capacity of between 10,000 and 20,000 kw. The reactor would be built at Halden near the pulp and paper mills of the large Saugbrugsforeningen Co., and would be used to produce some of the steam needed by Saugbrugsforeningen for its production processes. Research work would also be conducted. The Institute estimates that the reactor could be completed in three years and cost about £1,250,000, of which £1 million would be the cost of uranium and heavy water.

Saugbrugsforeningen is the second biggest user of steam in Norway. Its requirements are about 100 tons/hr. The atomic reactor could supply 10 to 20 tons. The Norwegian Institute for Atomic Energy, which already has a small reactor at Kjeller, visualises the new reactor mainly as an experimental plant to give practical experience necessary for the construction and running of industrial reactors.

## PHILIPPINES

### Cement project

A new cement manufacturing plant, capitalised at 10 million pesos, to be located in the province of Bulacan, is being organised. The plant is to have an initial capacity of 10,000 bags/day.

## The Leonard Hill Technical Group—September

Articles appearing in some of our associate journals this month include:

**Food Manufacture**—Concentrates from Soft Fruits: Their Preparations and Storage; Thermal Conductivity of Fruit Juices; Canadian Sardine Canning; World's Largest Sauerkraut Factory; Jersey's First Refrigerating Plant; Old-Time Potted Meats; Lecithin in Baking; The Chemistry of Peanut Butter Production, 2; Paying for New Machines.

**Manufacturing Chemist**—Adrenergic Inhibitors, 1: Classification and Structure; Manufacture of Perfumery Chemicals, 3: The Cinamic Series and Some Miscellaneous Compounds; New Laboratories for Water Pollution Research; Hecogenin Acetate Production; Italian Pharmaceutical Engineering; Progress Reports: Analytical Chemistry, Detergents and Detergency, Perfumery and Essential Oils.

**Paint Manufacture**—Solvents for Nitrocellulose Lacquers; Conjugation in Drying Oils; Fluorescence to Order; Fire-Retardant Paints.

**Fibres**—Molecular Bonding Aids New Textile Finishing Processes, 1; Industrial Uses of Artificial Fibres, 3; Fibre Data Sheet: Polyacrylonitrile Fibres; Improved Glass Fibre Paper; Textile Microtechnique; Fibres made from Synthetic High Polymers: A Report of a Conference in East Germany; International Congress of Scientific Research Applied to the Textile Industry, 2.

**Petroleum**—Plant Calculations for Petroleum Technologists, 3: Heat Transmission; Lubricating Grease; Review of Welding Equipment.

**Corrosion Technology**—Corrosion Research Laboratories, 5: The Battelle Memorial Institute; Staining of Engineering Components; Russian Ideas on Painting Machinery.

**Atomics**—Report of the International Atomic Conference, Geneva, 1; The Dekatron in Nuclear Instrumentation; The Long-Term Aspect of Fission Product Disposal; British Equipment at Geneva, 2.

## UNITED STATES

### Isobasic acid process

Synthetic isobasic acid in pilot-plant quantities is being produced by U.S. Industrial Chemicals Co., a division of the National Distillers Products Co., for evaluation by research and development groups in the chemical industry.

The company states that its isobasic acid is made by a novel synthetic process, starting with metallic sodium and butadiene. Suggested applications are for use in high-quality plasticisers for vinyl resins, synthetic lubricating oils for jet aircraft, polyurethane foams, and resins for reinforced plastics.

### Pentaerythritol plant

Hercules Powder Co. are starting construction of a new plant to produce pentaerythritol. The plant, representing a total investment of about \$6 million, is scheduled for completion late in 1956. It will double the company's present annual capacity.

To be located on the site of an existing Hercules anhydrous ammonia plant at Louisiana, Missouri, the new facility will have an annual production of 24 million lb. of pentaerythritol and 100 million lb. of formaldehyde.

### Plasticisers and chemicals plant

Celanese Corporation of America has announced that construction work will start in October, for completion in April 1956, on the first unit of a new chemical manufacturing plant at Gallipolis Ferry, West Virginia. The new plant will produce plasticisers, fire-retardant hydraulic fluids and compounds and a range of intermediate products for general industry.

### Sulphuric acid plant

Plans for the construction of a 100-tonns/day sulphuric acid plant at Tuscaloosa, Alabama, are nearing completion and building work should start shortly, according to Reichhold Chemicals Inc. The facility is expected to be completed in March 1956.

The project, with auxiliaries, will represent an estimated expenditure of close to \$1 million. Output of the new plant will be used by Reichhold in the many items it now manufactures.

### Chemical plant lawsuit settled

The lawsuit between Texas City Chemicals Inc. and Chemical Construction Corporation has been settled to the satisfaction of both parties, it was announced recently by the two companies. The suit, filed in April 1954, involved claims and counter-claims concerning contracts under which Chemical Construction Corporation was to design and construct for Texas City Chemicals Inc., at Texas City, Texas, a dicalcium phosphate plant, a sulphuric acid plant and facilities for the recovery of uranium from phosphate rock.

The plants are now in commercial production.

### Antibiotics enterprise for Japan

Formation of a new company for the basic manufacture of antibiotics in Japan has been announced by the Pfizer company, the world's largest manufacturer in this field. The new firm will be known as the Pfizer-Taito Co. Ltd. and its president will be Katsunobu Masuda, who is also

executive vice-president of Taito Co. Ltd., one of Japan's principal penicillin producers.

The new company will undertake the expansion of present production facilities at Kobe and will prepare for the basic manufacture of terramycin and tetracycline. Plans call also for future production of vitamins and steroid hormones.

#### New fibres laboratories

Celanese Corporation of America will shortly establish new development laboratories at Charlotte, North Carolina, which will serve as a link between fibre research at the Summit, New

Jersey, laboratories and commercial production at fibre plants. The laboratories will permit added emphasis on pilot-plant phases of research and development. Initially, it is planned to provide the buildings, services and staff for the development of manufacturing processes for new fibres.

#### Chemical industries' exposition

The 25th Exposition of Chemical Industries is to be held in Philadelphia from December 5 to 9. Displays to which space has been allotted embrace chemical substances and all manner of equipment required for their manufacture.

## Heat Exchange and Sudden Changes of Pipe Section

INVESTIGATIONS on the effect of sudden changes in pipe section on the heat-transfer coefficient have revealed that an abrupt convergence could cause as much as a threefold rise in the heat-transfer coefficient immediately after the change of section. By allowing for this effect, designers can economise on material.

In a heat exchanger, much of the heat transfer takes place under disturbed flow conditions due to bends, changes of section, and valves and other fittings. The effect of various irregularities on the heat transfer between pipes and fluids flowing through them is being studied under the Mechanical Engineering Research Board of the D.S.I.R. The first part of this work has been an investigation into the effect of an abrupt change of section.

An experimental aluminium-bronze 'pipe' comprises 18 ft. of 2-in.-internal-diameter pipe joined to 9 ft. of 1-in.-diameter pipe. Water flows

through the pipes from a constant-head tank and by reversing the direction of flow the effect of an abrupt convergence or divergence can be studied. Heat is generated in the pipe walls by passage of a direct current of up to 5,000 amp.; the thickness of the walls is such that heat is generated at the same rate per unit length of both the 2-in.- and 1-in.-diameter pipes. The temperature of the outer surface of the pipes is measured at a large number of positions with copper-constantan thermocouples, and from these measurements the corresponding temperatures of the inner surface are calculated.

Local heat-transfer coefficients for the abrupt convergence have been measured for both turbulent and laminar flow conditions. With fully turbulent flow abnormally large coefficients were obtained immediately after the change of section; these fell to normal after six to ten diameters.

The effect was comparatively small and it would seem that, where only a limited degree of accuracy is needed, existing formulae for predicting the effect of ordinary entry conditions into a short pipe may be used to account for the effect of an abrupt convergence; the effect can be neglected in a long pipe. The rate of heat flow had a slight effect on the coefficients, but this effect could not be precisely evaluated from these tests.

With the abrupt convergence and laminar flow, the variation in the coefficients was larger than with turbulent flow and persisted for a much greater length after the change of section; the effect would have to be taken into account in practical design. The heat flow had a considerable effect on the coefficient obtained, as natural convection made the top of the pipe hotter than the bottom. For very low rates of heat flow, the variation in the coefficients along the pipe from the change of section was in good agreement with that predicted from a simple formula assuming fully developed laminar flow at entry.

The effect of the abrupt divergence has been measured for turbulent flow. The variation in heat-transfer coefficient was much greater than with convergence, and steady conditions were not attained until about 12 diameters after the change of section. The form of the variation along the pipe was substantially independent of Reynolds number in the range 2,000 to 45,000, but the values of the coefficient fell slightly at the higher Reynolds numbers. The effect of the divergent change of section can be taken into account in practical design by assuming the pipe to be 8 to 15 diameters longer than its actual length.

The work, which has been described in the 1954 annual report of the Mechanical Engineering Research Laboratory (H.M.S.O., 3s.), is to be extended to include different diameter ratios. Air will also be studied as the working fluid. The modifying effect on the results of keeping the pipe at a constant temperature is to be considered.

Research on heat and mass transfer in the presence of chemical and phase changes is being carried out under extra-departmental departments. The use of artificial promoters to encourage dropwise condensation is being investigated; this work was referred to in our May issue (page 183). Promoters with an extended life have been synthesised and are being tested in a cross-Channel steamer and a power station.

### CHEMICAL & PROCESS ENGINEERING ENQUIRY BUREAU

Stratford House, 9 Eden Street, London, N.W.1

Readers requiring names of suppliers of raw materials, machinery or finished products should complete this form and attach it to their business note-heading. Please state approximate quantities required.

We wish to know names and addresses of suppliers of the following :

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Date

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